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ABSTRACT

Background information, activity suggestions, and recommended resource materials comprise this guide for designing a week-long ecology unit for junior high school students on Coastal Awareness. Discussed is how various physical processes such as waves, currents, and tides affect rocky shores, marshes, sandy beaches, and estuaries. To encourage teachers to study coastal ecology with their students, about 30 related indoor and outdoor activities are briefly described. In addition to an annotated bibliography of 160 publications, the resource materials section also lists recommended films, data sources, and Sea Grant institutions. (WB)

Coastal Awareness:

A Resource Guide For Teachers in Junior High Science

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Coastal Zone Management

September 1978
Washington, D.C.

Prepared By:

Frederick A. Rasmussen
Curriculum Consultant

RDD Consultant
Boulder, Co. 80303

FOREWARD

This series of Resource Guides on Coastal Awareness in Science was developed for elementary, junior high and high school teachers who would like to instill in children and young adults an appreciation of the ecologic value of the coast. Each of the Guides contains concepts, and activities which could be used in a week long unit on Coastal Awareness. The purpose of this guide is not to present a definitive work on coastal ecology, but to entice teachers to explore ecological aspects of coastal awareness. A more complete understanding of the coast requires study of the interactions of ecology with economics, humanities, and government.

As state governments develop coastal management programs, citizens must make choices as to the most important uses of the coast. An understanding of coastal ecological processes will aid students as they participate in future decision making.

The Coastal Awareness Series in Science includes:

- Coastal Awareness in Elementary Science
- Coastal Awareness in Junior High Science
- Coastal Awareness in Seniro High Science

These are available from the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, 3300 Whitehaven Street, N.W., Washington, D. C. 20235.

RWKnecht

Robert W. Knecht
Assistant Administrator
Office of Coastal Zone Management

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Teachers who evaluated the guides were:

David Madfes, Lowell High School, San Francisco
Karen E. Reynolds, Havenscourt Junior High School, Oakland
Joan E. Steinberg, Lafeyette School, San Francisco

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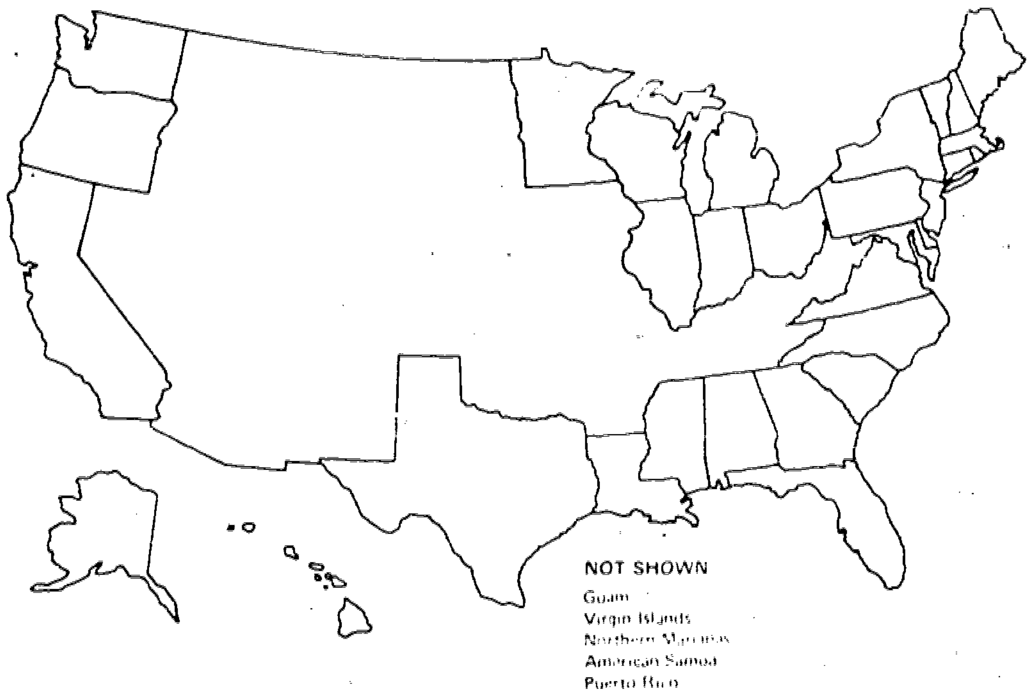


THE COASTS

The shore lines of the United States--where the land meets the sea--measure more than 140,000 km (88,000 mi). If straightened, they would stretch more than three times around the equator of the earth. Our nation's coasts include the sea shores of the continental United States, Alaska, Hawaii, four Atlantic island groups, and nine Pacific island groups. The Great Lakes and all the sounds, bays, creeks, and rivers washed by tidal waters are also included.

What are the special characteristics that define a coast, that make coasts valuable and vulnerable to human activities? Why and how should we protect this vital area of our nation?

The coast is a place of untold natural resources. It is a place to which one can escape, a place to play, to be serene, to be inspired. In near-shore ocean waters fish can be caught for sport or for food, and the coast itself can be a significant agricultural area. Each coast has a different history, different pressures, and different problems. Yet, in a physical sense, many of their problems may be similar.

Pollution is one such common problem. The Great Lakes are the largest fresh water resource in the world. Pollution of these lakes, which began in the 1800's, has continued steadily: forests were cleared, disrupting the natural balance, and increases in population, industry, commerce, and recreation continue to encroach.

The development that has plagued the Great Lakes for a century is only just beginning in Alaska. But changes come quickly where the margin for life is narrow, and in the frigid waters of the Bering Sea there is little room for error. The Bering Sea is literally the "fish basket" of the northern hemisphere. It supports a surprising variety of life, including one of the largest marine mammal populations of the world, what may well be the world's largest clam population, one of the world's largest salmon runs, some of the largest bird populations per unit area, the world's largest eelgrass beds, and unusually high numbers of bottom-dwelling fish.

Any coast consists of two primary elements: the water and the land. The area where these meet--the coast--has unique characteristics due to periodic inundation and continual changes in salinity. The biological composition of the coasts is often in delicate balance.

The science student concerned with the coastal zone will want to investigate both the water and the land as well as their interaction. Coastal waters are generally rich in nutrients that have been carried from the land by the rivers and streams. Near-shore coastal waters are particularly productive. These waters are a basic resource; they are affected by a variety of factors--the forces that cause tides, the winds that augment the waves, and the activities of human beings, including exploration and exploitation.

THE SHORE

There can be other definitions, but for our study, we define the shore as the narrow strip between the high-water and low-water marks of spring tides. Thus, there are regular, yet extremely variable local environments. First, the sea covers and uncovers the coastal area twice daily. Temperature ranges may be great within a single day. The salt concentration may vary greatly. The extent to which this intertidal zone is uncovered at low tide depends on the sharpness of its slope which in turn depends on a variety of factors including the nature of the land, its configuration, and the action of the tides, currents, and rivers.

The three basic types of shore are rock, sand, and mud. They are often mixed together. The waves have the greatest influence on molding the shore as they break against the land, washing away loose materials, eating into hard rocky coasts, and sometimes forming an abrasion platform at the base of high cliffs. Powerful crosscurrents deposit banks of sand that have been formed by the disintegrating rocks. Mud flats occur at the mouths of rivers or in sheltered creeks and inlets where the sediment brought from the land is deposited. Ice, weather, and the elements all work to help form the shore.

Plants and animals are other factors in coast building. Plants may act to bind sand and mud together into dry land. Encrusting animals may serve to protect rocks or to destroy them. Light plays a significant role in this environment, affecting growth of vegetation which, in turn, affects animal growth and survival.

Estuaries, too, affect the shore environment. Dilution by fresh water will occur at the mouths of rivers, while increased concentrations of salt will occur as a result of evaporation during the summer.

OCEAN IN MOTION: WIND, WAVES, CURRENTS AND TIDES

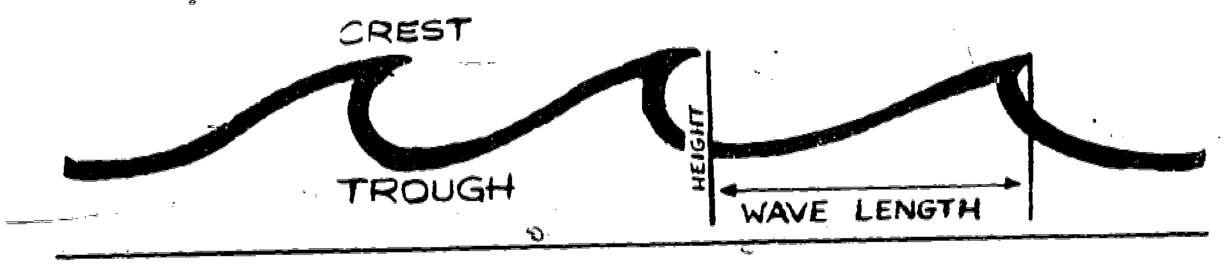
Wind generates waves. The wind, blowing irregularly, causes significant pressure differences that deform the water's surface, creating wave crests of many heights. The wind then pushes against these crests, supplying energy to the waves as they grow and become more regular in height and length. Wave growth depends on four factors: wind velocity, distance of open water over which the wind has blown (called the "fetch"), duration of the wind, and the state of the sea (waves that were present when the wind started blowing).

The wind also plays a part in coast formation. In addition to their indirect effect through action on the water, powerful winds can cut into rock, tearing away gravel that slides to the water's edge. They may also pick up grains of sand and pile them into dunes.

WAVES

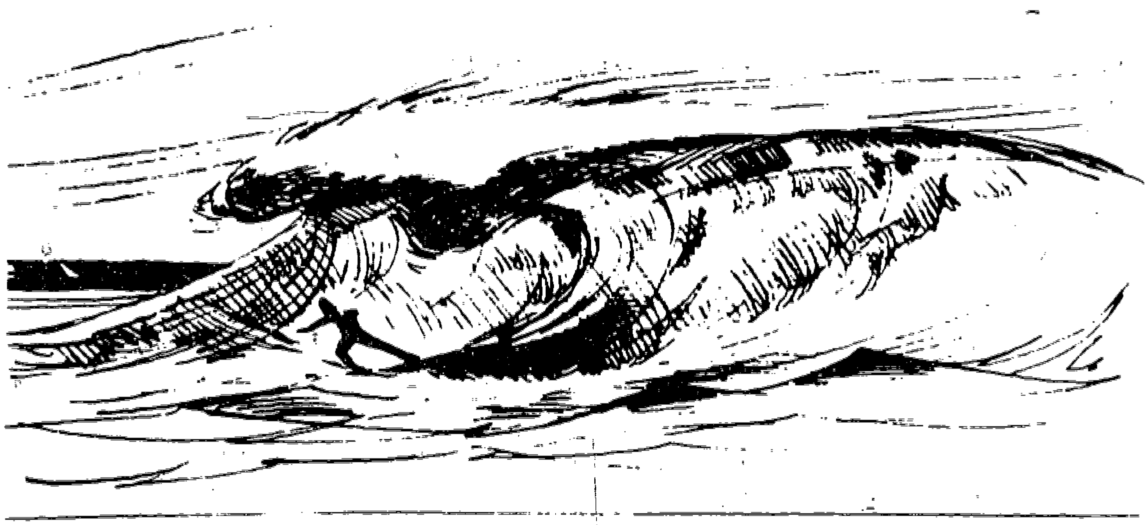
Waves are the sculptors of the coasts. Forceful or gentle, loud or lulling, they combine two distinct types of motion. One is the circular motion of the water molecules within the wave, the up and down motion of the droplets. The other is the advancing movement. The actual water molecules have no horizontal motion as the wave advances through the ocean.

Waves are described by their height, length, velocity, and period. Period is the number of seconds it takes for two successive crests to pass a stationary point. Height is the vertical distance from the crest (high point) to the trough (low point) and length is the distance from one crest to the next. Period, length and wind velocity are interrelated. Wave height, however, is not related to these factors. The height of a wave in meters is usually about one-tenth the wind's speed in kilometers per hour.



As they move away from the winds that started them, waves tend to expand laterally and to become lower, more rounded, and more symmetrical. They then move in groups of similar size, called "wave trains"; the individual waves are called "swells." Once a wave train has formed, it will continue to travel over the sea until it either breaks on a shore or is flattened by opposing winds or wave systems. (In these materials, we will be concerned in particular with the breakers because of their effect on the coastal area.) As a swell approaches the beach, the topography of the ocean bottom takes effect. Depending on wave length and bottom contour, waves may break at depths from one-half to three times their height.

The bottom slope is the key determinant not only of the depth at which a wave breaks but also of the manner in which it breaks. A steep bottom results in a wave that retains all its energy until the last possible moment, when the crest peaks up suddenly and plunges violently forward into the trough. As the crest folds over it becomes concave, creating a "tube" or tunnel of air on the shoreward face. These are known as "plunging waves." Hollow plunging waves are the most challenging for surfers because their steepness makes for a very fast ride and it is often possible to crouch under the falling crest--to be "locked in the tube." The plunging waves that curl over the dangerously shallow coral reefs of Hawaii's "Banzai Pipeline" are a famous example of this kind of wave.



A gradually shoaling bottom results in a wave that releases its energy more slowly. When a crest finally becomes unstable, it rolls down or spills into the trough and the wave face remains gently sloped. It is these "spilling waves" that display white water at the crest.

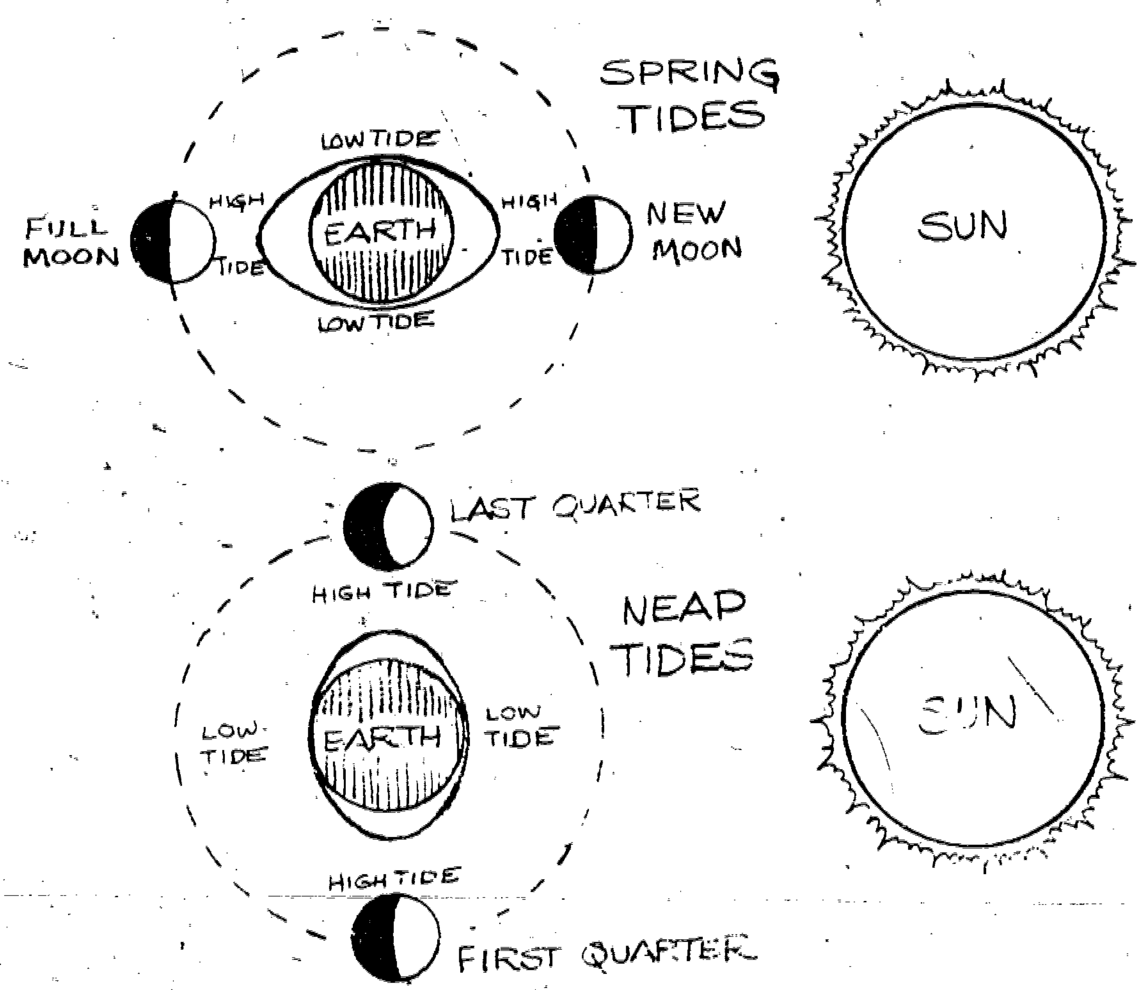
Irregularities in the ocean bottom tend to make waves spill rather than plunge. Even long-period waves break as spillers on a flat sloped beach, but any suddenly shallow spots will cause most waves to "suck out" and plunge, regardless of their periods. Most surf zones are in a state of constant change.

Wind is not the only generator of waves. Earthquakes on the land or under the sea may cause a drastically low tide that is followed by destructive giant waves (sometimes called tsunamis) hurling relentlessly against the shore.

TIDES

The tides are important in determining the character of the coast. Tides result from the effect on the waters of the gravitational attraction among the sun, moon, and earth.

The masses of the earth and the moon exert a gravitational pull on each other that affects every particle on earth, including water. The force is greatest on those particles nearest the moon, but it is much smaller than the earth's force. Although the force required to pull water vertically off the earth would be great, a much weaker force can pull the water horizontally, in effect sliding it across the face of the earth. Water is drawn toward the point directly "below" the moon, and high tides occur when water piles up in this way. Identical forces cause comparable effects on the side of the earth farthest from the moon. In both cases, the water moving into the high tide is being drawn away from another region of the earth. Thus, there are high tides on opposite sides of the earth on a line directly extended between the moon and the earth, and there are low tides midway between the two high tides, in the area from which water for the high tides was drawn.



Due to the changing position of the moon, a tidal pulse sweeps around the surface of the earth, causing secondary waves that move across the oceans. In mid-ocean the secondary waves may be only as high as 1 meter, but where the water is shallow these sea waves become much higher. The increased height is the result of a tremendous friction force which slows the wave down. When such tidal pulses move through narrow channels, the water is "bottled up." The highest tides occur in these narrow channels; a well known example of such tides is the Bay of Fundy between Nova Scotia and New Brunswick in Canada.

Because the earth and the moon move orbitally (the earth around the sun and the moon around the earth), both the timing of the tides and their range vary in response to these gravitational forces. The greatest difference between high-water and low-water is found at the "spring" tide, when sun and moon exert their force in the same direction during the new or full moon. The highest tide is during the new moon when the moon is in line with the sun, with the earth between them, and the gravitational pull is all in the same direction. The smallest, or "neap" tide occurs when the high-water mark is at its lowest, and the low-water mark is at its highest.

CURRENTS

The forces that keep the great mass of ocean water in motion are many and varied; important among them are the heat of the sun and the rotation of the earth.

As the sun warms the surface water at the equator, the water expands and raises the surface just enough to cause a gentle slope. Water at the equator therefore runs downhill to the poles. The heavier polar cold water sinks and spreads slowly along the bottom of the ocean toward the equator. This interchange of warm equatorial waters with cold polar waters is complicated by a variety of additional forces. For example, the earth's motion toward the east affects the water on the surface of the earth both directly, by causing waves to pile up, and indirectly, by creating winds. The spin of the earth also results in the Coriolis effect -- the tendency of water (or any moving object) to turn slightly to the right in the northern hemisphere and slightly to the left in the southern. Consider the Atlantic Ocean waters in the region just north of the equator, where the Gulf Stream originates. Heated by the tropical sun, the salt concentration of the water steadily increases as a result of constant evaporation. Meanwhile, the trade winds (a consequence of the earth's spin) continually blow over the warm, salty waters, pushing the surface waters in a westerly direction toward the north coast of the South American continent. The waters then move toward the Caribbean Sea and on, northwesterly, into the Gulf of Mexico where they pile up, raising the surface level. Following its natural tendency to seek equilibrium, the water drops into the Florida Straits, the only possible egress. From there the Gulf Stream runs northward along the coast.

As the Gulf Stream moves north it trends increasingly toward the right (to the east) because of the Coriolis effect. By the time it reaches 40° N latitude, it is flowing due east across the Atlantic, has lost considerable speed, and has widened; it has also cooled down. Currents similar to the Gulf Stream move the waters of the Pacific, Indian, and other oceans.

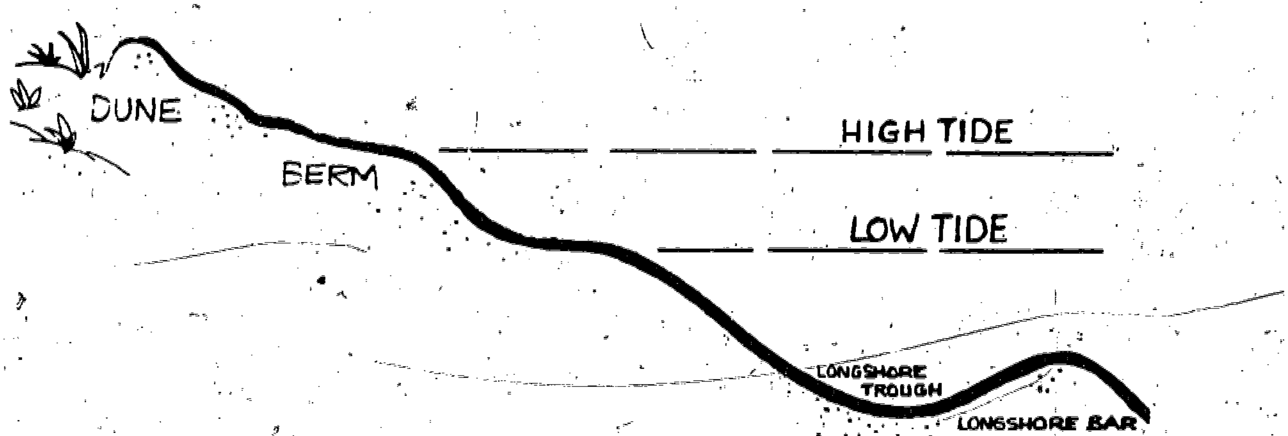
Other factors affecting water currents include ice floes moving from polar seas on the cold currents. As the ice moves southward it cools the water. Since cool water is heavier than warm water, it sinks and is then replaced by warm water near the surface.

The most economically important currents are upwellings of cold bottom water. This vertical motion brings to the surface an unusually heavy concentration of nutrients. When offshore winds drive surface waters out to sea, they are replaced by the upwelling nutrient-rich deep water. Mineral-rich waters from the land add to the nutrient supply. This upwelling supports a rich growth of phytoplankton, the start of a complex food chain, and makes possible intensive commercial fisheries such as those off the coast of Peru and the Grand Bank off the coast of Newfoundland, Canada.

THE SANDY BEACH

Of all the coastal elements, sandy beaches probably have the highest recreational value. These beaches vary considerably from one part of our

country to another. They have different sand, different waves and winds, and different dunes and other inland formations. They are composed of grains as diverse as the black lava sands of Hawaii, the golden sands of Lake Michigan, the white coral sands of Florida, and the seemingly endless sandy expanse from San Diego to Los Angeles. Florida's popularity as a vacation land almost certainly is in large part due to the fact that so much of its coastline is sandy ocean beach.



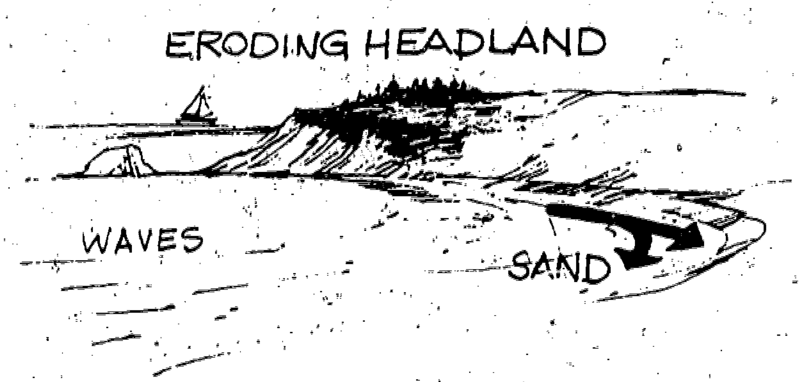
A TYPICAL SANDY BEACH

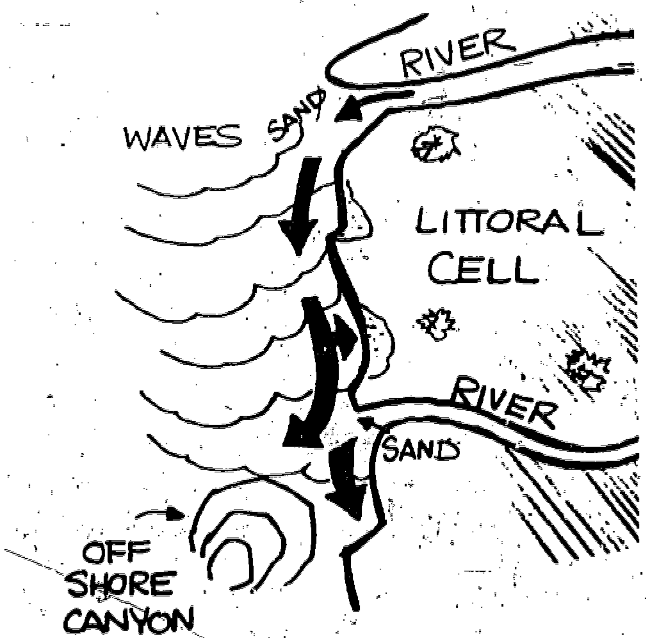
Although sandy beaches differ in many ways, they also share certain characteristics. A cross section of almost any sandy beach in early summer would probably reveal a structure like that shown above. Waves moving onshore break on the longshore bar and roll up onto the beach. Each wave moves sand from the longshore bar and slowly, almost imperceptibly, a longer more sloping beach is created. Then, as the season changes, blustering winter winds and heavy seas begin to attack the sloping summer beach. The winter waves are higher, steeper, and closer together than those of summer. Sometimes sand is carried away from the berm and even from the dunes or other land areas behind the berm. This pounding winter wave action generally deposits some sand on the berm, but it carries away far more sand and deposits it in longshore bars, setting the scene for another yearly cycle.

The texture of the sand plays a role in the kind of beach that will be built, because the slope of the beach relates directly to the particle size of the deposited material. The coarser the particles, the more the waves sink into the beach, depositing their load of sand. Since coarse sand does not pack down and is easily moved around, steep beaches result. When the particles are finer the sand packs down more tightly; the waves do not sink in, and their action leaves a harder, smoother, and gentler slope.

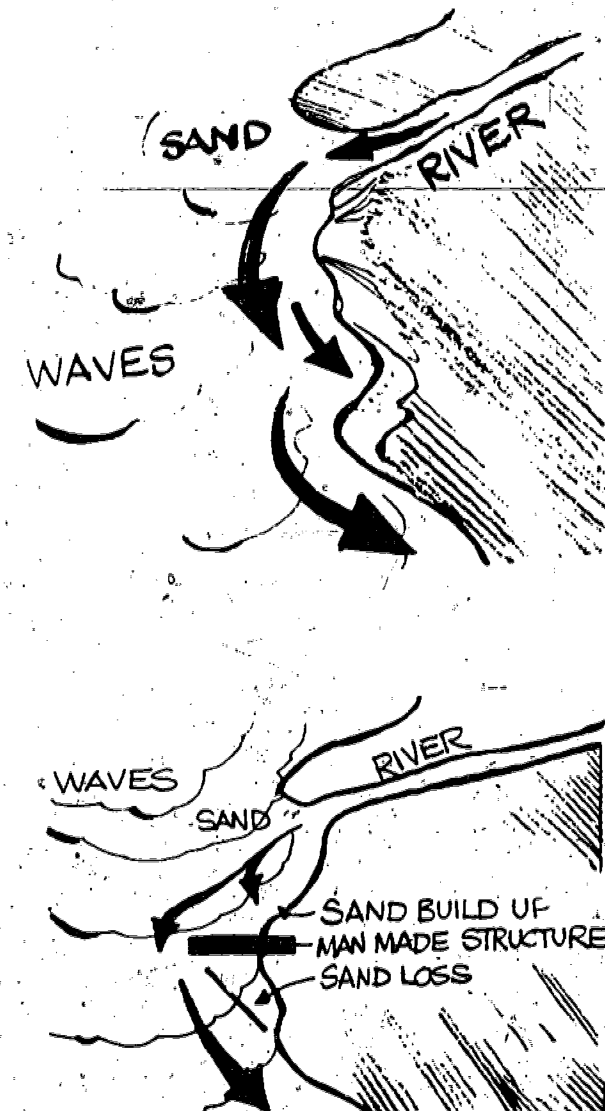
Waves and wind thus work endlessly building, shaping, and reshaping beaches. Large particles grind against each other, creating progressively smaller fragments. The largest of these are dropped on the beach and smaller less dense particles are carried out to be deposited in quieter, deeper regions of the ocean.

Regardless of the season, the markings on sandy beaches are intriguing. The graceful swash marks left by an ebbing morning tide are composed mostly of detritus -- fragments of once living things--that are not only a source of food for many beach inhabitants but are also a treasure trove for human beach explorers. Parallel ridges and troughs, called ripple marks, are often seen on sandy beaches: if the ripple marks are in dry sand they were caused by wind, but if they are lower down on the beach they were caused by moving water. Whether caused by wind or water, the process of ripple formation is essentially the same. When wind or water moving over the sandy surface meets an obstacle in the surface it turns downward, excavating a trough. The sand thus thrown up creates another obstacle and the wind or water then creates another trough.





LITTORAL CELL



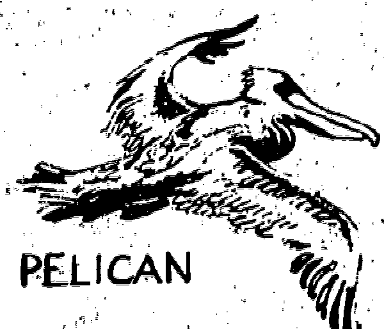
LONGSHORE MOVEMENT

Ocean beaches are moving, active places that gain and lose sand continuously. Beach sand is transported by waves, wind, and wave currents in three kinds of movements: offshore, on-shore, and longshore. When put into suspension by wave action, sand can move laterally along the shore in longshore currents at the same time that it is being moved offshore and returned onshore. Sand movement along the shore occurs within relatively distinct sections of the coast, sometimes called "littoral cells." The boundaries of a cell extend from the place where sand is introduced onto the shoreline (generally by a stream to the place where it is swept out to the sea. Where beach indentations in the coast are isolated from the general sand movement of the "cell" within these areas, shore erosion and onshore currents can supply sand to smaller "pocket" beaches.

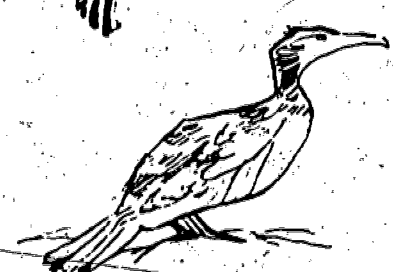
Human activity often has had disastrous effects on the natural supply of sand to beaches. Reducing high water runoff from rivers seriously reduces the sand supply available since it reduces the erosion along river banks. Improper construction of groins, jetties, and breakwaters can change the distribution of sand by longshore currents, causing excessive sand buildup in some places and sand loss in others. The biological production of shorelines is also affected when normal water circulation patterns are changed. Careful study is needed before any major beachfront modifications are under taken.

The long stretches of sunbaked sand and the breaking waves that delight vacationers are also what make sand beaches among the most barren of coastal environments. Because of its shifting nature, the sand offers a poor substrate for anchoring plants. Thus, beaches essentially lack the producers in the food chain and the few animal residents of the sand must depend on small wave-borne particles for food. Usually such residents are tiny crustaceans or mollusks which live in the moist upper surface of the beach close to the water line and filter the food from the retreating waves. Other crustaceans and sand hoppers inhabit the uper beach, feeding at night along the tide line. Each sunrise they dig new burrows often peppering the sand with their holes.

Sand beaches are superb places for bird watching. Some birds are full-fledged swimmers and obtain their food from the ocean and the near-shore ocean bottom. Others parade incessantly up and down the beach at the water's edge in search of food. The specific kinds of bird inhabitants vary from one part of the country to another, but certain general kinds can be recognized. Medium-sized birds



PELICAN

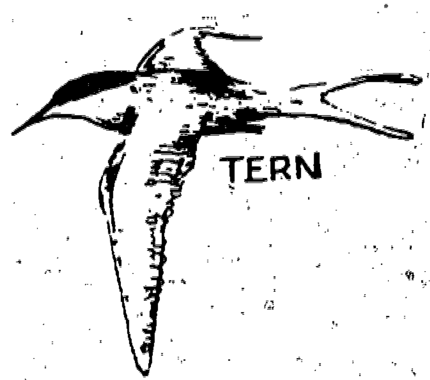


CORMORANT

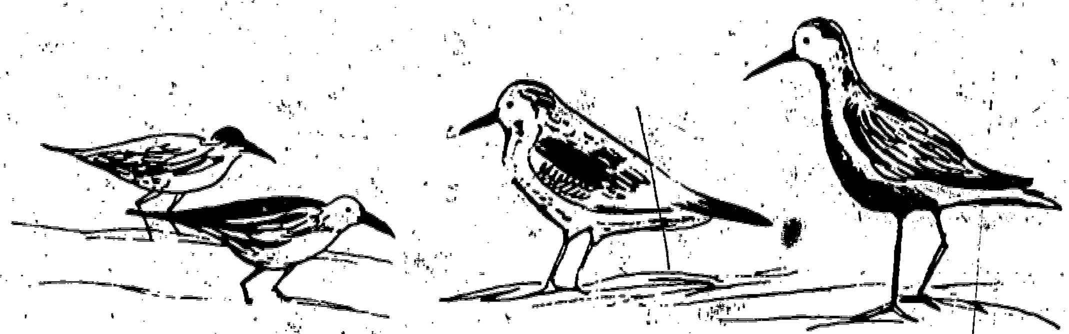
that are flying across the surface of the water or riding on it are likely to be gulls, terns, or cormorants. The cormorant is a dark bird that dives and disappears for a considerable time while swimming in search of food. Gulls and terns do not swim under water. Terns can be seen flying over the water and diving into it to catch small fish, but gulls are less likely to dive for their food. Gulls, either singly or in groups, can also be seen on the beach itself in search of food. A group of large birds flying gracefully in formation just above the surface of the water is probably a flock of pelicans.

GULL

Sand pipers and plovers are the smaller birds that run up and down the beaches, carefully avoiding the breaking waves. They are generally long-legged, small to medium in size, and inconspicuous in color. Their food consists of animal and plant fragments that have been cast onto the sand by waves and the tiny animals that live in the upper surfaces of the sand.



TERN

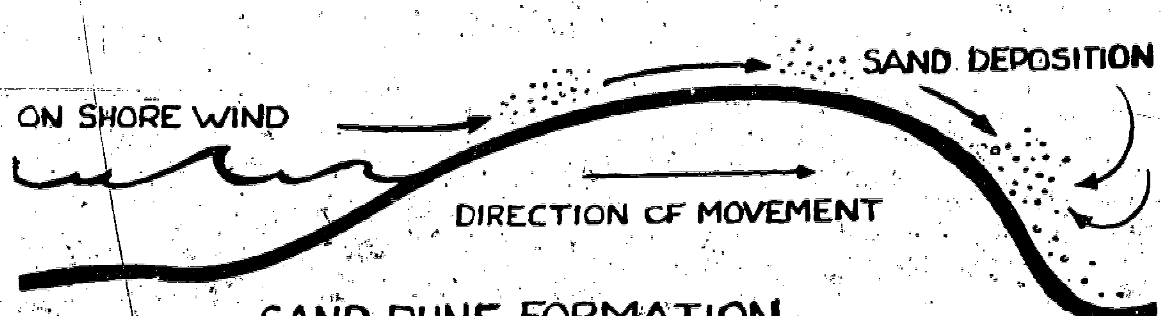


SHORE BIRDS

SAND DUNES

Sand dunes form when large amounts of sand are blown inland from a constant source of supply such as a beach. Where the wind is slowed by a log or clump of grass, it drops its load of sand, and a mound slowly builds up. As the mound grows, more sand is deposited behind it; growing larger and higher, the mound becomes a small hill, a ridge, and finally a dune. Wind-blown sand blowing up the face and falling down the crest gives the dune its characteristic shape - a long sloping windward side and a steeper slope on the lee side. If nothing interferes with the wind or anchors the sand, the dune creeps inland as the wind moves sand from the windward to the lee side. The rate at which a dune advances can vary from a few centimeters to many meters per year. A fast-moving dune can bury everything in its path.

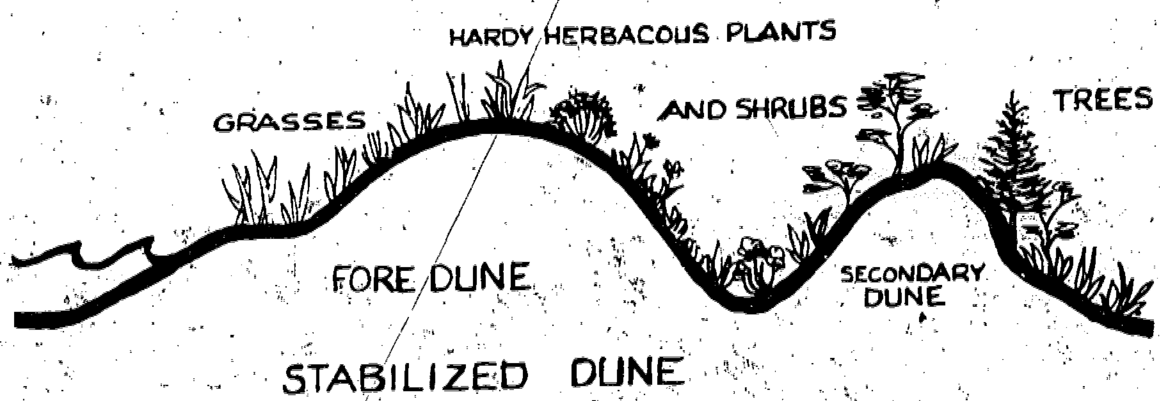
The movement of sand dunes may be slowed by the invasion of pioneer plants that can root and grow in the shifting sands; often it is grasses, such as Marran grass --or Poverty grass-- which begin the stabilization process. After the clumps of grass have become established, shrubby plants can take root on the lee face of the dune. Protected from the wind



SAND DUNE FORMATION

and with their roots close to the water table, these shrubs often form dense thickets, providing shelter and food for small mammals and birds.

Dune life tends to progress from that of bare sand to dense woodland, but this progression can be halted and hundreds of years of growth destroyed in a very short time. Hurricanes, fires, or construction (the building of homes, cottages, or roads) can disrupt the stability that took so long to establish. When a break in the vegetation mat occurs, the wind can quickly charge through it, tearing at the roots of nearby plants. As successive clumps of plants are exposed, more and more sand is released, and the dune begins to move again.



ROCKY SHORES

Rocky shores are the coastal areas where the confrontation of land (continent or island) with the ocean is most evident. Here the rocky underpinnings are ceaselessly attacked by moving water, sometimes on a spectacular scale. For example, on our Pacific shores, where wind-driven waves can build up over almost 10,000 km (6,000 mi) of open ocean, the surf is as violent as anywhere in the world. Even normal winter storms generate 6m (20 ft) waves that break against the shore with a shock equivalent to an automobile striking a wall at about 145 km/h (90 mph).

Even though the glass beacon on Tillamook Rock light house on the coast of Oregon is some 42 m (140 ft) high, a grating had to be installed over the glass to protect it from rocks tossed up by the pounding seas. Of course, not all rocky coasts are as exposed as Tillamook Rock. Offshore islands, reefs, and headlands provide protection from the pounding surf when they are in the direction of the prevailing winds.

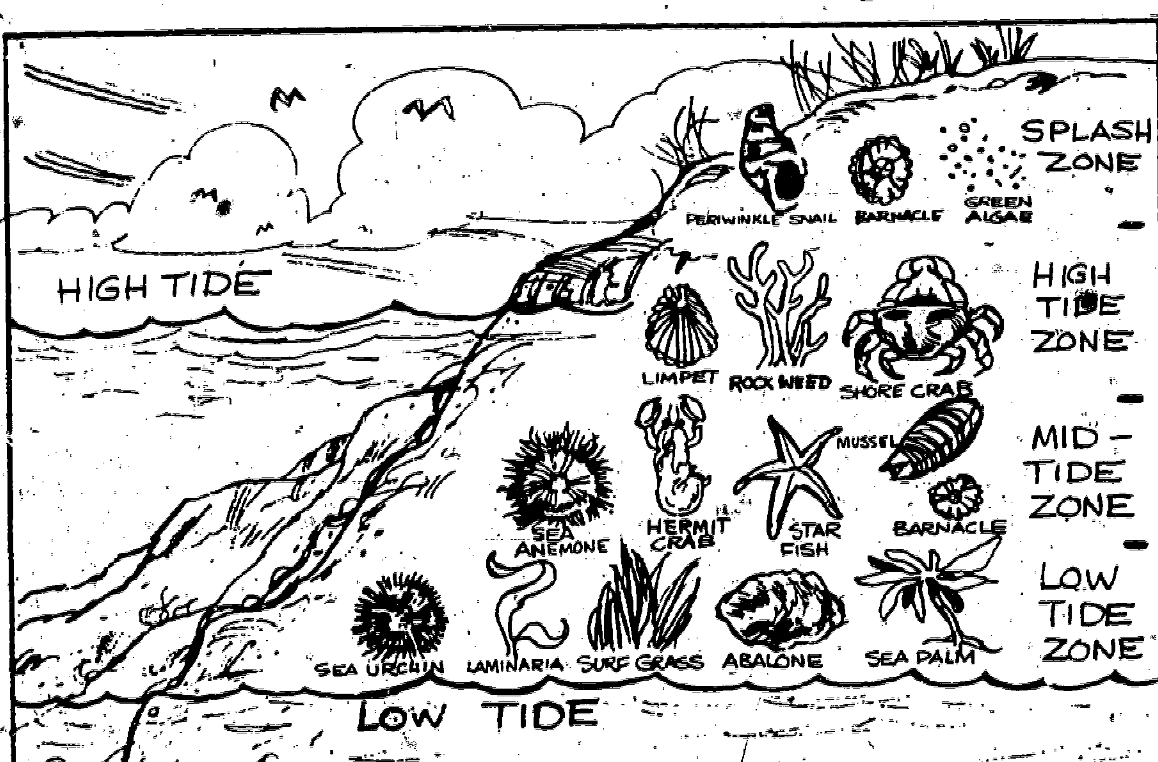
The composition of the rocky shores of the United States varies significantly from one place to another. In the northeastern United States, shorelines are made up largely of metamorphic and intrusive igneous rocks, but those on the southern Atlantic coast might be sandstone, coarse shell gravel, or coral. Continental Pacific coasts are largely sedimentary rock, and the Hawaiian coasts are igneous rock. The shores of the Great Lakes have rocky coasts, some of which are formed by older sedimentary rock and others by ancient metamorphic rock. Since the nature of the rocky substrate, the rate at which it erodes, the forms produced by erosion, and the mineral content released are so variable, it is not possible to deal with these factors in a publication of this nature. Teachers who want to explore the rocky coast should research their coastal zones in one of the publications cited in the bibliography.

The kind of biological communities that will live on any particular rocky coast is determined largely by the degree of exposure to open surf, and by the extent of tidal exposure. Life forms can vary significantly from one side of an island or a headland to the other because conditions which regulate life are so different. Regardless of their exposure to violent surf, rocky shores are much more active biologically than sandy ones, for they offer a solid, unmoving (albeit hazardous) place where both plants and animals can attach and survive. Thus, rocky shores are better than sandy ones for providing opportunities to observe a wide assemblage of marine organisms.

Significant differences in the appearance of the marine shoreline are evident at high and low tides. A careful observer can see the orderly progression of plants and animals. These species lie in horizontal "belts" across the shore, one strip above another.

In many places, these strips (or zones) are brightly colored by the resident organisms and therefore sharply delineated; a view of them from the shore is often startling. On other coasts such zones may be less obvious and more difficult to distinguish, but they are rarely absent.

Local zonation may vary considerably. Zones of a rocky face directed seaward will differ from zones facing the land or from those at right angles to the shore. Zones on a smooth, sloping rock surface may be immediately apparent whereas a shore of broken rock lying at random angles may seem not to have a pattern of zones at all. Similarly, the zones found on sunlit slopes are noticeably different from those in areas shaded by overhanging rock.



TIDE ZONES OF A ROCKY SHORE

Adapted from <u>Marine Advisory Publications</u>

Turbulence governs the life of organisms living between tidemarks on rocky coasts. Even when the ocean surface appears to be calm, there is usually a swell which explodes when it strikes the coast. Animals that live there seem to prefer this turbulence, and the highly aerated water it produces is crucial to their existence.

Organisms living near the upper tide mark must be able to resist desiccation during low tides. Many intertidal organisms have developed anchoring methods that keep them in place even during storms which batter them for hours on end. By and large, it is the adaptation of such organisms to life under very special conditions that governs intertidal zonation.

The extreme variations found in coastal areas in the United States make it difficult to recognize the zones between tidemarks. The following definitions of the intertidal subdivisions may therefore be helpful.

SPLASH ZONE

The splash zone is the area of transition between water and land. Although it is affected by spray, it is covered by water only at the highest tides or during storms. Animals that might inhabit this area are the periwinkle snail and the pill bug.

HIGH TIDE ZONE

Where the high tide zone is most fully developed, barnacles form a dense, almost continuous sheet on the rocks. Often this sheet has a sharp upper limit which is a very conspicuous part of the shore line. On some shores limpets are present with the barnacles. Rock weed can be found in the lower edges of this zone.

MID-TIDE ZONE

Each day the mid-tide zone is usually uncovered twice (at low tide) and covered twice (at high tide). Animals found here are seldom found in the deeper waters that are not as affected by tidal fluctuation. Sea anemones, star fish, mussels, and hermit crabs are frequently found in this zone.

LOW TIDE ZONE

Only during the very lowest tides, once or twice a month, is the lowtide zone exposed to view, and then only briefly. Animals found in this zone can also be found in deeper water. The animal and plant populations of this zone are large and varied. In cold temperate regions, these populations consist of forests of the brown algae with animals and an undergrowth of small plants on their holdfasts. Coral reefs commonly include or encompass the upper edge of the rich growth that extends down the reef face below low-water level. In warm temperate regions the low-tide zone may support dense colonies of tunicates and other ascidians, as well as dense growths of red algae.

Before visiting your coast consult a local publication which describes in some detail the organisms present and their distribution. Living organisms should be observed where they are found, not collected. Disturbing the shore line in any significant way is to be avoided at all costs.

Remember that rocky coasts can be dangerous places to observe, especially at low tide when the tendency is to walk out as far as possible. Even on relatively calm days unpredictable large swells may develop, so careful watch should be maintained.

ESTUARIES

An estuary is a partially enclosed body of water connected to the open sea; thus, the seawater is diluted by fresh water draining from the land. An estuary is the site of forceful interaction between sea, land, and air.

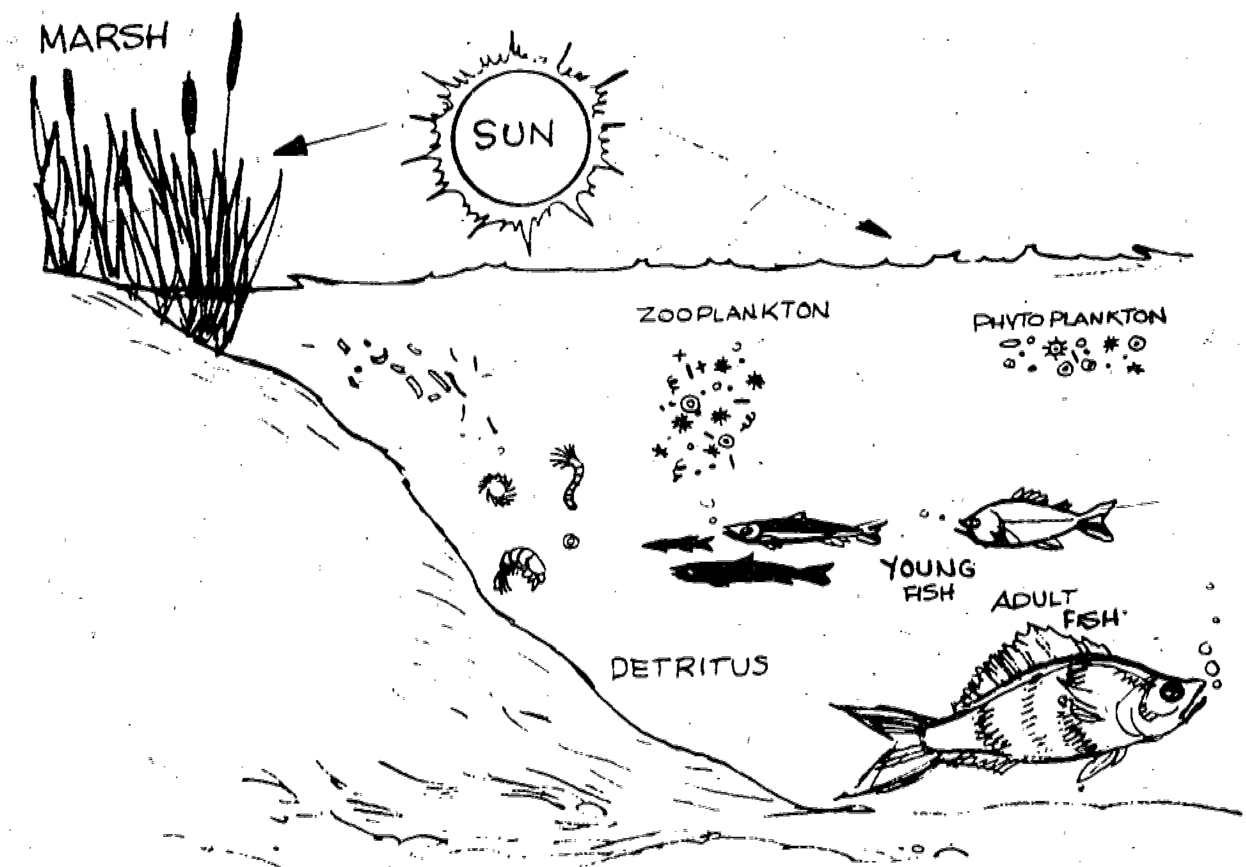
Along the coasts of the United States there are almost 900 estuaries of many different types. Along the Atlantic coast there are drowned-valley estuaries, exemplified by Chesapeake and Delaware Bays. Estuaries that developed behind barrier beaches are found at Ocean City, Maryland, and at Biscayne Bay, Florida. In contrast, the estuaries along our northwest Pacific coastline are majestic glacier-gouged fjords, where the rivers are contained by steep rocky slopes. Earthquakes, land shifts, and other violent actions have created estuaries such as San Francisco Bay.

GENERALIZED CIRCULATION IN AN ESTUARY

Despite some very apparent differences, some characteristics appear to be common to estuaries: fresh water at the river end, salt water at the ocean end, and a mixing system between them. In most estuaries the salinity gradient ranges from 30 to 35 parts of salt per thousand parts of water at the ocean end and to zero salinity at the river end. Water samples from estuaries usually show that deep waters are more saline than shallow waters-- that is, a vertical gradient of salinity exists. This gradient not only moves up and down the estuary with the ebb and flow of the tide but also responds to high and low flows of river water. The net transport of the less salty water at the top is seaward, while the saltier water moves inland along the bottom. Thus, a stratified system, with a distinctive pattern of circulation evolves, resulting in the movement of surface organisms toward the sea and of bottom organisms toward the river.

Although the circulation patterns in estuaries have many characteristics in common, different estuaries may have significantly different flow patterns. For example, in the delta of the Mississippi River, the volume of fresh water is so great that the fresh water overruns the salt water of the Gulf of Mexico and a tongue of less saline water extends far out into the salty Gulf of Mexico. In Chesapeake Bay, where the outflow of fresh water and the saline tidal inflow are nearly equal, a distinct salinity gradient is formed and the water stratifies within the estuary. A variety of other factors (such as the nature and slope of the bottom, and the force of prevailing winds, the amount and timing of rainfall) also affect the circulation and salinity of estuary waters.

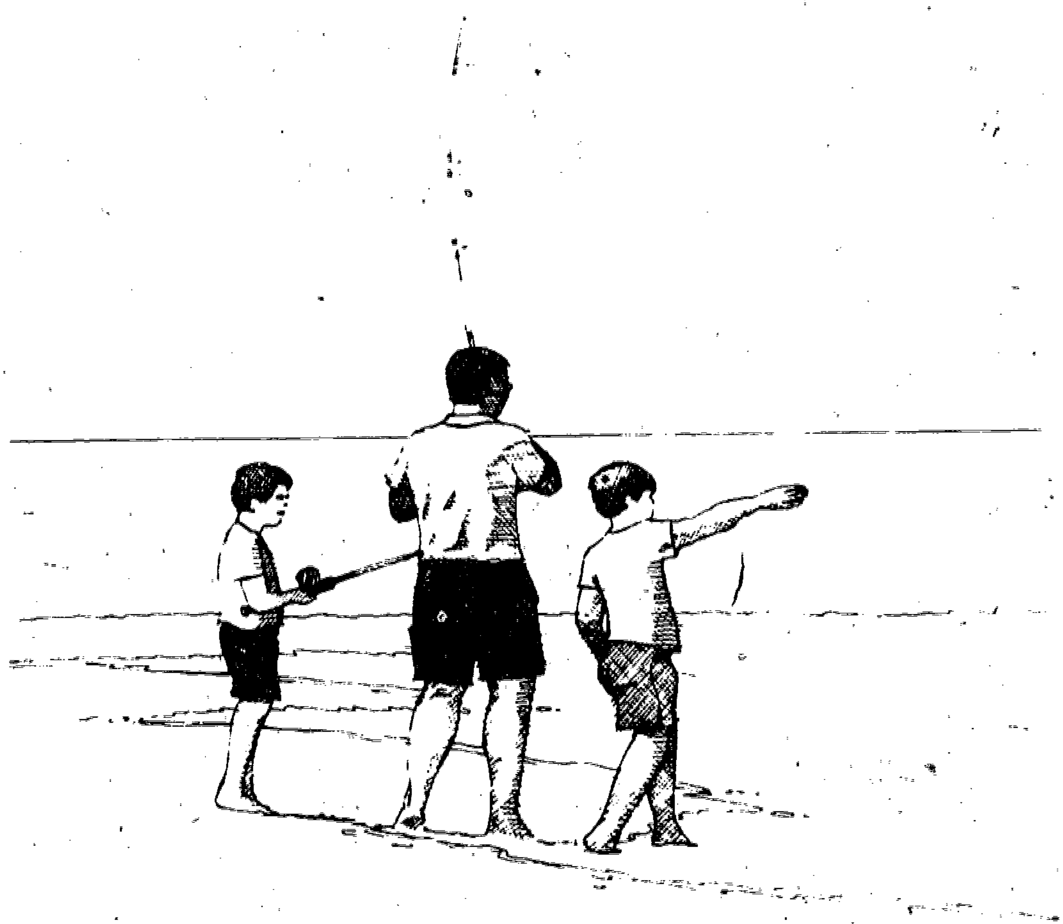
Rivers flowing into estuaries carry with them erosion products and detritus which tend to settle out as the current slows in the estuary. As they near the bottom, these sediments tend to be carried inland with nutrients carried in from the ocean; this creates a kind of nutrient trap that makes estuaries highly productive eco-systems. At the same time, the constant input of solid material from the river outflow contributes to the filling of the basin or to the creation of a delta extending into the sea. Unfortunately this deposition of solids also serves to trap contaminants such as heavy metals, pesticides, pathogenic bacteria, and toxins. Increasing densities of industry and population along coasts could thus produce unforeseen but far-reaching and permanent detrimental effects on the biological production of estuaries.



ENERGY - FOOD RELATIONS IN AN ESTUARY

The food chains in estuaries include two distinct populations of primary producers - phytoplankton and rooted aquatic plants at the edges of the estuary. The abundant zooplankton present include larvae of most of the organisms that live in the estuary. The behavioral patterns of many species of zooplankton keep them within the circulation pattern of the estuary and prevent them from being washed out to sea.

Benthos (bottom-dwelling species) are usually more abundant in estuaries than in either fresh or salt water environments. These species are quite diverse, ranging from annelid worms through a variety of crustaceans and mollusks. Many feed by various filtering processes, an effective way of trapping the nutrients flowing through the estuary. Oysters and clams are the most commercially valuable of these filter feeders harvested by man.



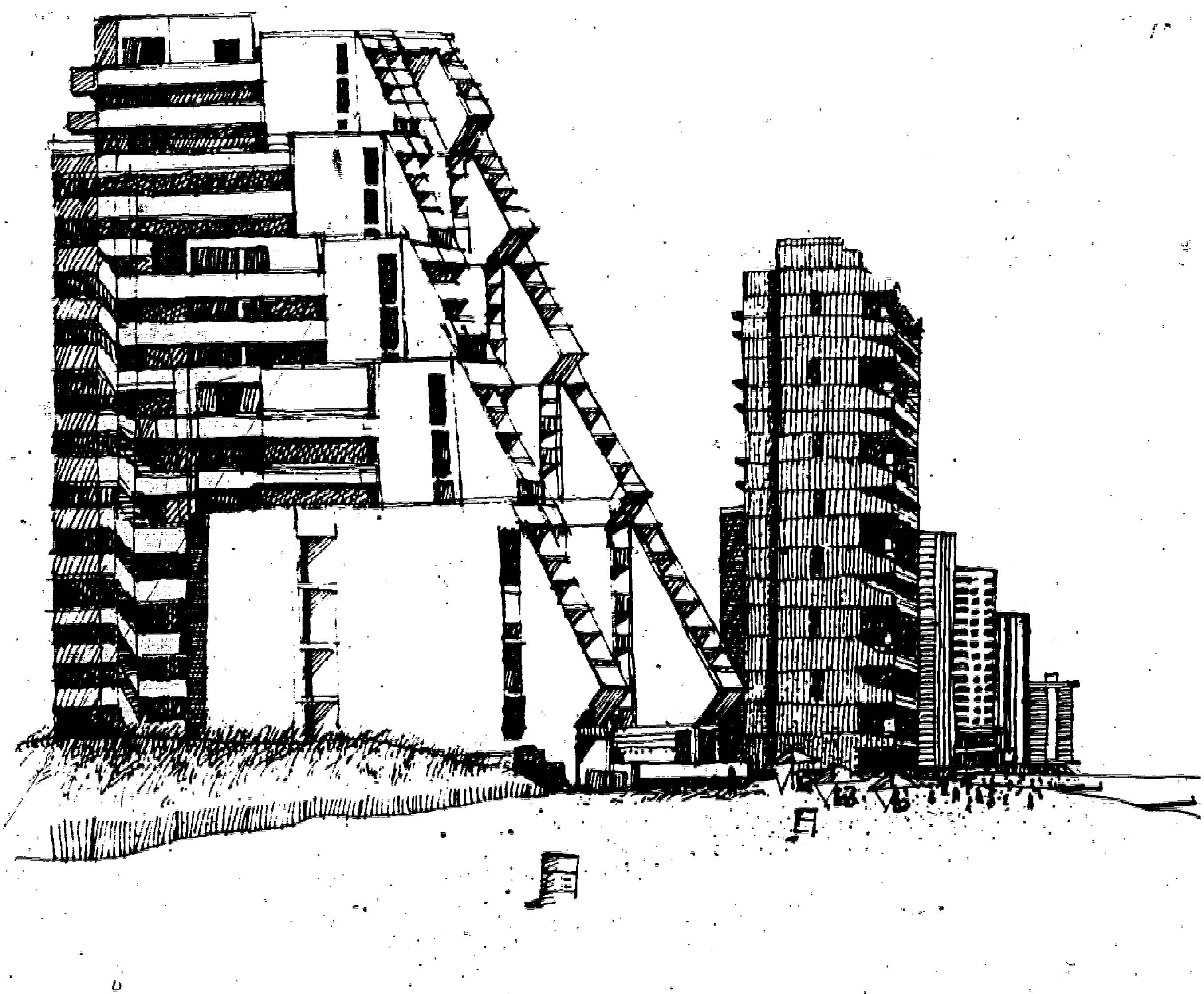
The benthic populations range from fresh to marine environments, but the most dense beds are often near the center of the estuarine system. The distribution of the oyster, for example, seems to be controlled primarily by three factors: the upstream limit is set by the maximum flow of fresh water from the river; the downstream limit is set by predators and parasites which are found only in high salinities; and the lateral limit depends on the presence of a relatively firm channel shoulder.

Among our coastal fishes the most commercially valuable species are either partly or entirely dependent on estuarine environments. Fish use estuaries in many different ways. Some populations of striped bass spawn near the interface of fresh and low-salinity water, others move farther into the rivers, and some populations are even adapted to fresh water. In an estuary, eggs and larvae drift downstream. The developing fish feed throughout the system until they are adults and the cycle begins again.

Anadromous fish, such as the shad or salmon, spend their adult lives in the open ocean but return to fresh water to breed. Shad also use the estuary as a nursery for the first summer before the young fish move to the ocean. In contrast, the croaker, which also depends on the waters of estuaries for reproduction, spawns at the entrance to the estuary and the young are transported upstream to the plankton-rich, less saline part of the estuary, where they develop before returning to the ocean.

Open ocean fish, such as the bluefish, whose early life histories are totally marine, migrate into estuaries as adults to feed on the abundant food available there.

These varied patterns of estuarine use are concurrent as each species follows its own seasonal and reproductive sequence. Thus an estuary may include the regular or occasional presence of several hundred species of fish. The low-salinity portion of the estuary is of exceptional importance since it receives the eggs, larvae, and young of fish with different kinds of spawning patterns. Although this aspect of the estuary is highly valuable, its value is not obvious because these stages in the life cycle of fish are not immediately recognizable. Since many large cities are located near estuaries close to the head of navigable waters, this potential impact merits special attention.



MARSHES

Marshes are broad wet areas where grasses grow in abundance. When they are located along the margins of ponds, streams, or rivers, they are freshwater marshes. When they are found on ocean coasts or along the banks or margins of estuaries, they are salt water marshes. Salt water marshes are the nurseries of the sea. They are the most productive land on earth, producing three times more than the best wheat lands.

Biologically, marshes are transitional between wet and dry areas, and they are usually very productive in terms of the biomass they can support. If undisturbed by nature or man, most marshes gradually fill with detritus and are eventually invaded by dry land plants.

In freshwater ecosystems, marshes contain such water-tolerant species as cattails, bullrushes, horsetails, arrowgrass, flowering rushes, buttercups, crowfoot, and many types of grasses. These marshes are also homes for many aquatic insects, amphibia, crayfish, isopods, birds, and aquatic mammals; when they are associated with permanent bodies of water, they may serve as nurseries for young fish. Lake St. Clair (a very wide area in the isthmus connecting Lake Huron with Lake Erie), which has extensive marshy areas built on the silt deposited from Lake Huron, is one of the most productive freshwater fisheries in the world.

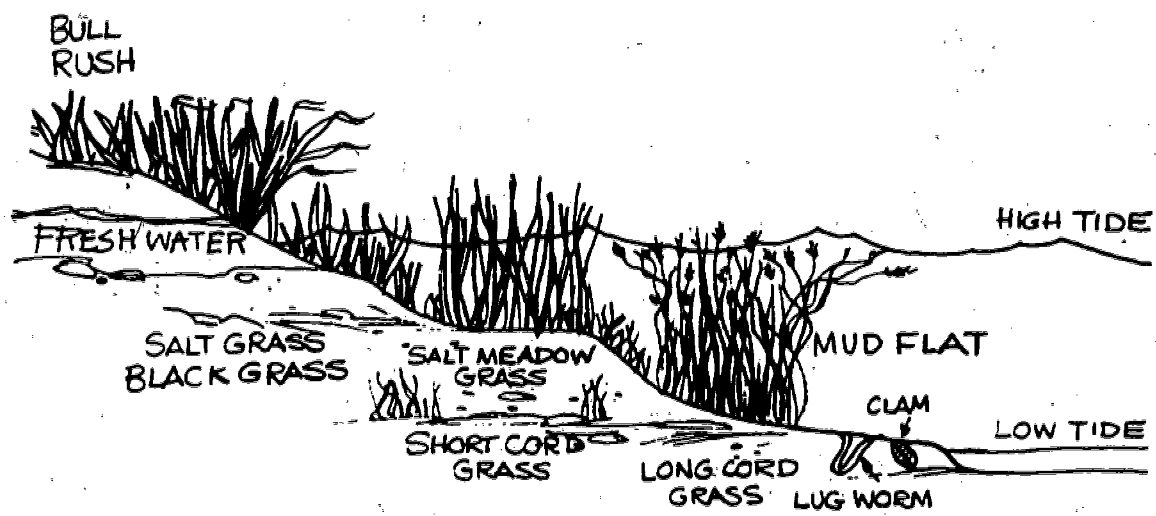
Salt water marshes can best be classified by their relation to the land or the ocean. Of all salt marshes, the most maritime (bearing the closest relation to the ocean) are those that develop on relatively open coasts. They are bathed in sea water at almost full strength since the freshwater drainage from land is usually minimal. These marshes are usually rich in algae, including freeliving species and tiny forms of the brown algae derived from normal forms that are attached to rocky shores near the marshes.

Marshes at the mouths of estuaries, usually found in the lee of coastal spits, are the next most maritime of the salt marshes. The coarse-grained soils of these marshes are subject to stronger saline influence than those of marshes further up the estuary. As their distance from the ocean increases toward the middle and upper reaches of the estuaries, the marshes tend to become progressively more terrestrial since the water becomes progressively fresher.

Despite the wide range of conditions in the United States under which salt marshes exist, some general statements about their formation and the distribution of organisms within them can be made. Salt-marsh formation usually starts in an area that is subject to twice-daily salt water (tidal) inundation. Salt-marshes are replaced by freshwater marshes at the upper level of tidal influence, where tidal inundations occur only a few times a year. Between these two extremes, plants and animals thrive according to the range of conditions they can tolerate -- conditions that are dominated by the tides at the lower levels--and almost independent of them at the upper levels.

Some factors of crucial importance to the survival, growth, and reproduction of organisms in the intertidal zone are the intensity and frequency of mechanical disturbance due to tidal movement; the vertical range over which the tide operates, which determines flooding depths and the vertical extent of the marsh; the form of the tidal cycle, which determines both the frequency and the length of submergence and emergence; and the water quality, which determines, among other things, the amount of light reaching submerged growths and the salinity to which they are subjected.

Grasses are the most prominent plants in salt marshes. Cord grass in a long and a short form, is the grass most likely to live in marsh areas covered by water at high tides. Other salt-tolerant plants and plants tolerant to salt spray make up the upper edges of the marsh and vary with the locality.



A TYPICAL SALT MARSH

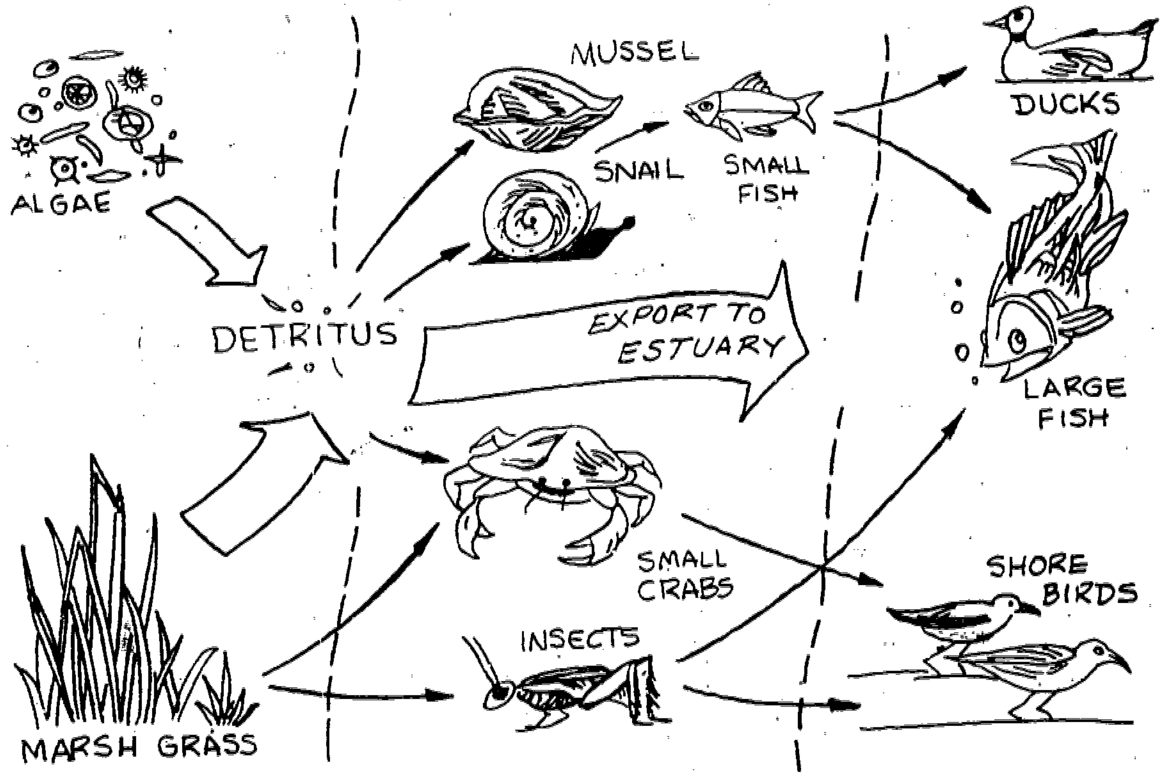
Animals are widely distributed in salt marshes and the adjacent mud flats, although their distribution patterns are not as obvious as those of the plants. Mud flats are occupied by burrowing creatures such as marine worms and clams, which are fed on in turn by other organisms. Fish come in with the tide to feed on the abundant small forms of life that occupy the marshes. Birds are prevalent in marshy areas. Some, such as the marsh wrens, swallows, ducks, geese, herons, and rails nest in or around marshes and get most of their food from them. Mammals such as raccoons, mice, rats and, less often, otters and mink inhabit marshes and feed on other organisms that live there. Marshes are also crucial stopping and feeding stations for flocks of migratory birds.

Marshes are rich in numbers of species as well as numbers of individuals. Species with aquatic larvae, such as mosquitos, gnats, and dragonflies are well represented. Other species, such as grasshopper and cricket, enter the marshes to feed.

In a terrestrial grassland, energy conversion relies on direct consumption of green plants. In contrast, energy conversion in salt marshes relies on decay as the chief link between primary and secondary productivity. Only a small proportion of marsh grass is grazed while it is still alive. Not only is the role of phytoplankton in energy production in marshes less than it is in open water, but also cloudy water or turbidity may diminish algae productivity by reducing the amount of light available for photosynthesis.

The food chain of nature is complex. Each step up the chain involves a a decrease in the number of organisms and an accompanying increase in the amount of food they consume. At the bottom of the food chain, 1000 pounds of phytoplankton will result in 100 pounds of insects and small animals. In turn 100 pounds of insects result in 10 pounds of fish, ducks and birds.

Although it is not shown on this diagram, people are at the top of this steadily narrowing food chain. As in the other steps, it takes 10 pounds of ducks or fish to produce a one pound gain in human beings.



ENERGY CONVERSION IN A SALT MARSH

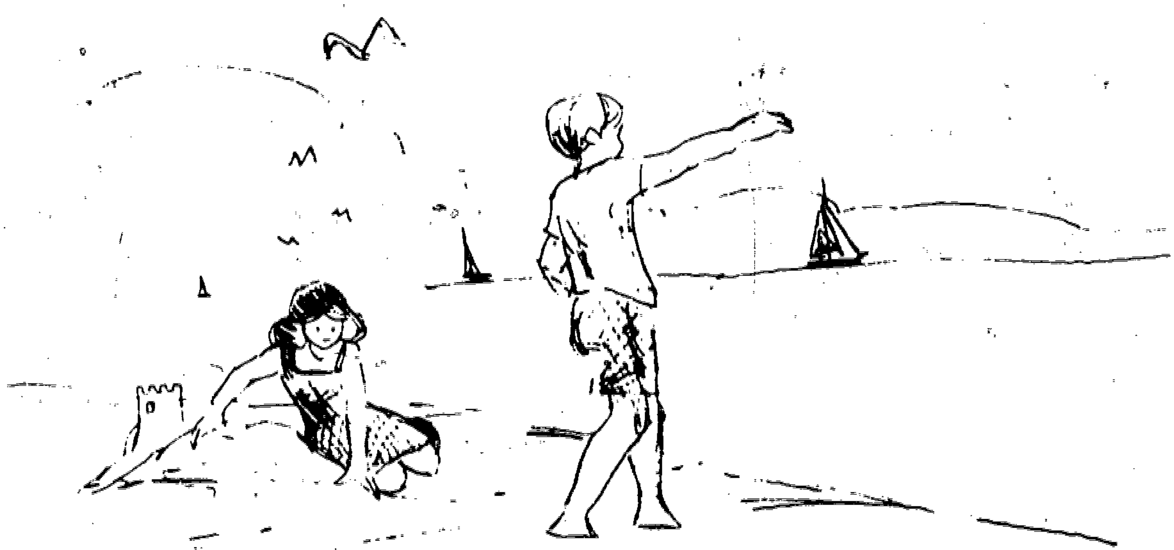
ACTIVITIES

Coastal Awareness Activities for Middle and Junior High School Students

Two elements are common to all activities suggested in this collection: each requires a concrete experience as a basis for learning, and each requires an action on the part of the learner. A range of activities is offered: some must be pursued at the seashore, others in freshwater environments, and still others in the classroom. Teachers are encouraged to offer the widest possible selection of activities to their students.

Since some of these activities involve children working at or near the water's edge, students must be instructed in how to behave in these potentially dangerous coastal areas. They must be instructed not only for their own safety but for the protection of the environment.

Teachers will note that suggestions are generally written as directions to students rather than to teachers. This is largely a space-saving device that allows for more rapid skimming of ideas to see what is available and suitable to your environment.

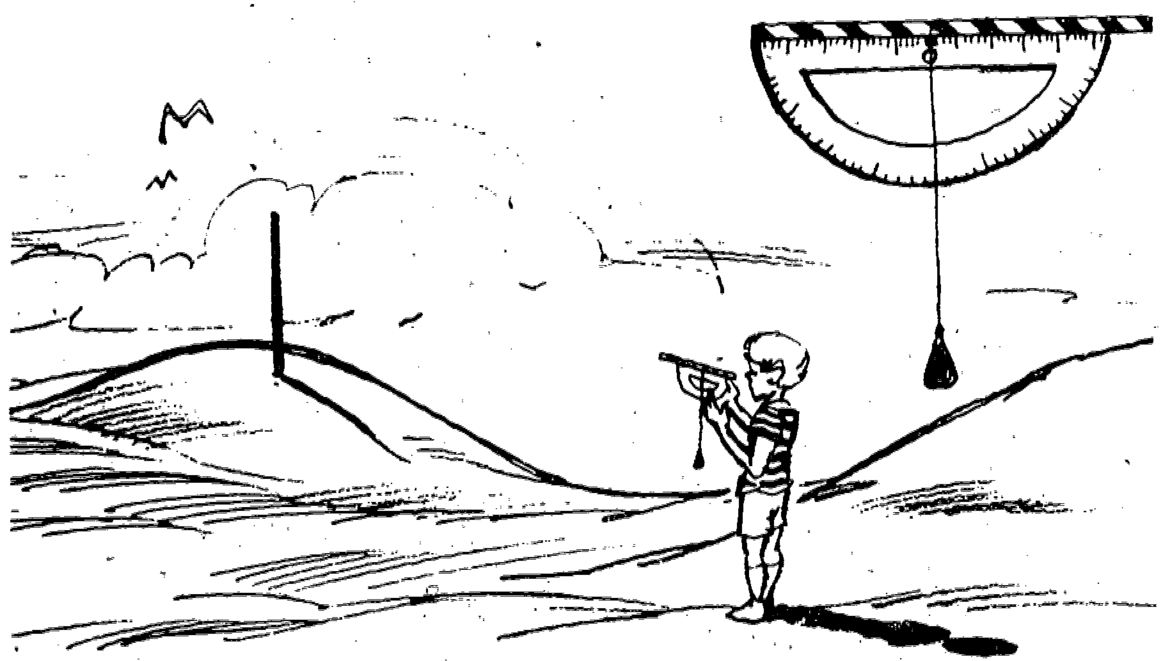


Beach Art

Make a sculpture or another art form from litter you collect at the beach. Take a picture of it to display in the classroom or at home. How should you dispose of your art work?

Measuring Sand Dunes

Make a clinometer (an instrument used to determine inclination or slope) by gluing a soda straw along the straight edge of a protractor and attaching a weighted string to the zero mark in the middle on the straight edge of the protractor. You also will need a stick that comes up to your eye level from the ground. Plant the stick at the top of a dune. From the bottom of the dune, sight through the straw to the top of your stick (the curve of the protractor will be on the underside of the straw). Note the angle of the string hanging down over the curved side of the protractor. Subtract this number from 90° (vertical) to find the angle of the dune. Measure the front and back angles of the dune. Which is the steeper? Which would slide more easily? Can you pile sand from that dune at a steeper angle than the back slope?



Ideas for Coastal Observations

Visit a rocky beach at low tide. Take along pieces of fresh shrimp or fish and feed small crabs or anemones; describe how they respond. How many other kinds of living things can you see in the tidal pool?

At low tide, put some mud from a tidal flat on a piece of window screen and wash it gently with water. Describe what you see. Look at some dock pilings while the tide is still out. How is the part that is covered at high tide different from the continuously exposed part? Describe any living things you see on the piling.

Put a stick in the sand where you think the high tide will just reach it but not wash it away. Watch to see what happens.

Using Tide Tables

People who live near oceans can plan exploratory trips to the sea shore more effectively if they know what the tidal level will be when they get there. If you want to go to see the animals that live at the lower level of the intertidal zone then you should visit the shore when the tides are at their lowest ebb. You can find this information by getting a tide table for your local area. Reading a tide table seems difficult at first so practice on the sample below which was taken from a table constructed for Breakwater Harbor, Delaware. Tide tables give you six kinds of information:

OCTOBER 1970

Month	*Time*			*Year*	
Date	16	0236	-0.5		*Height of tide*
Day of Week	TH	0906	5.6		*(2 high tides and*
		1524	-0.4		*2 low tides)*
		2136	4.4		

The time is based on the 24 hr where 0000 is 12 o'clock midnight and 1200 is 12 o'clock noon. So 0236 would be 2:36 AM and 1524 would be 3:24 PM. The height of the tide is related to the mean low water level. A number preceded by a minus sign means the water level will be below mean low water. No minus sign indicates the height of the water above mean low water.

17	0318	-0.3
SA	0954	5.4
	1612	-0.2
		4.0
18	0406	0.0
SU	1042	5.2
	1706	0.1
	2312	3.7
19	0454	0.3
M	1136	4.9
	1800	0.4
20	0006	3.4
TU	0548	0.6
	1230	4.5
	1900	0.7

Using the information above answer the following questions.

1. What day of the week will have the highest tide?
2. On which date will the high tide be the lowest?
3. Which day would be best for looking for organisms farthest down the beach?
4. Using the 12 hour clock what is the best time to visit the beach on Sunday during high tide?

At high tide make a map of a small section of coastline. Put in rocks, curves in the beach, and the location of logs and other things that are lying on the beach. Make another map of the same place at low tide. Compare your maps.

Put a rock in the sand just below where the waves are washing up on the beach. Do this only if the waves are small and not dangerous. After each wave goes out look at the sand around your rock and describe what is happening.

Beach Currents

Is there a beach current? You can often determine the direction of beach currents by observing the direction taken by floating objects thrown into the surf. Brightly colored objects--balls or balloons partially filled with water--make good objects to observe.

Do the currents along your beach run parallel to the coast? Are they influenced by curving coast lines or headlands? Can you measure the rate at which the current is moving?

Mark off in the sand 50 or 100 steps and time how long it takes your object to move that distance.

Sand in Motion (Erosion)

Which way is the sand moving? Plant a stake in the sand midway between the highest wave mark and the low point of wave recession. Does sand accumulate on one side of the stake? Is it washed out from another side? Can you decide in which direction sand is being moved?

Measuring Tidal Change

Mark a stake in centimeter intervals, and when you arrive at the beach, drive it into the sand so that the water covers the lower part of the stake after the waves have receded. Watch the water level on the stake. Is the tide coming in or going out? Can you measure the vertical distance (up the stake) traveled by the water during your stay at the beach?

Oil Spills

How would a small oil spill affect your coast? You can use non-polluting material to represent drops of oil. Pick a dock or some prominence that extends out into the water as the place to have your "oil spill." Throw your simulated oil drops (leaves, shavings, or sawdust) into the water and watch what happens.

What factors determine where your spill reaches the coast? How big an area is affected? Which animals and plants collect the most "oil"? How would your oil spill affect recreation in your area?

Measuring Wind Erosion

Coat the top 10 cm of the sides of a short, square post (a four by four will work) with petroleum jelly. Sink the post into a section of sandy beach. Observe the post after 24 hours. On which side is the sand the highest? In which direction was the sand moving? What was happening to the beach--was it being built up or eroded? Does this pattern change from high tide to low tide, from day to day? What is the most sand that will collect by the post in one day?

Prints of Aquatic Plants

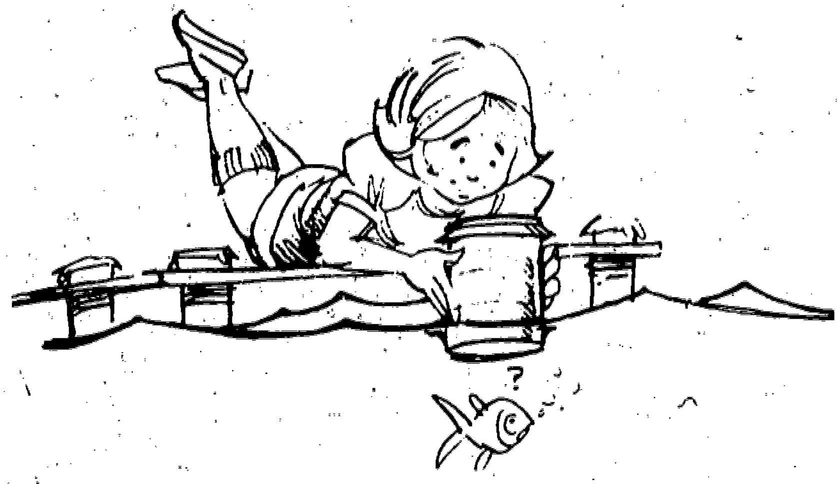
Buy some ozalid paper from a store that handles drafting supplies. It comes in a roll and you will have to cut it to the size you want in a dark room. Using glass, a piece of cardboard the same size as the glass, and masking tape to hold them together on one side, make a frame for exposing the paper. Then cut pieces of Ozalid paper to fit in the frame. Place a plant (or feather, or other material you collected from the beach) between the glass and the sensitive side of a piece of the paper. Press the cardboard against the paper, and hold the glass toward the sun. Red paper will take about 15-25 seconds of exposure, blue paper about 20-35 seconds, and black about 40-50 seconds. You may have to experiment to get the proper timing.

Remove the Ozalid paper from the frame in a shaded place. Roll into a cylinder, put it in a large jar containing a small open jar of concentrated ammonia, and cover the top of the large jar. The fumes from the ammonia will develop the print in 3 or 4 minutes. If prints are too pale, they were not exposed to fumes long enough; dark, heavy prints indicate excessive exposure. Use a fresh supply of ammonia each time you print; concentrated ammonia usually is available at drug stores. Household ammonia is not concentrated enough. Do not inhale the fumes from the jar.

Observing Barnacles

Take a plastic shoebox or similar container with you to a rocky sea shore. Find a rock that has barnacles on it that will fit in your container. Cover the barnacles with sea water, sit back, and watch what happens.

What is the function of the four plates on the front of the barnacle? When the barnacle opens, what comes out? Make a shadow across the top of an open barnacle. What happens? What happens when you put a few drops of fluid from a crushed clam or piece of fish near an open barnacle? When you have finished, carefully put your barnacle rock back where you found it.



Watching Aquatic Organisms With a Look Box

A "look box" will allow you to look into the water, on the bottom, and to see things not easily seen from above the water. To make your look box, remove both ends from a large (#10) can, and tape clear plastic wrap across the openings, or use your imagination to design your own kind of look box. Bring extra plastic wrap and tape with you to the coast in case your box is damaged. The secret to seeing with such a box is to move slowly and carefully, and to be patient.

How many kinds of moving animals can you see? How many are attached? Are the fish in the open or hidden? What kinds of plants do you see, and are they just in some places or everywhere? Make a sketch of the things in the small area you are observing.

Hermit Crab Houses

Do hermit crabs on the coast near you prefer to live in particular kinds of shells? Take several containers with you to a section of the coast where hermit crabs live. Pick a single tidal pool and carefully pick up all the hermit crabs you can find. Sort them into containers by the kind of shell they have. You don't need to know the kinds of shell--only how they look.

Count the number of crabs in each container and then release them.

Is one kind of shell preferred? Survey another pool to see if the choices are the same. Make a chart showing the shape of the shells and the numbers of crabs in each. Can you identify the kinds of shells used most often?

Populations on Pilings

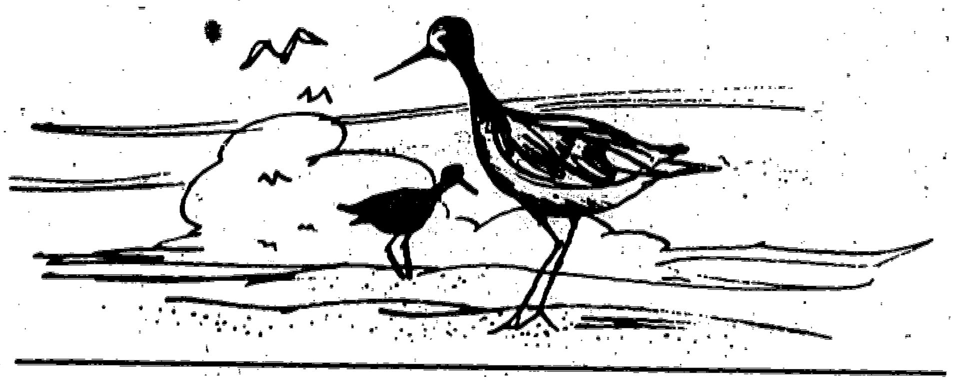
Is there a pattern to the way animals and plants grow on pilings in salt-water estuaries? Find a place where you can examine the underwater portion of several pilings during low tide; the lowest tide is the best time. Carefully observe and record the kinds of organisms present on one piling and the vertical space they occupy--that is, which organisms are highest on the piling, which the next highest, and so on. Then examine one or two other pilings. What are the common characteristics with respect to distribution of living things on the pilings? What are the differences? What do you think affects the distribution of these living things?

Bird Behavior

Find a comfortable place to sit along the coast in an area where you can see more than one kind of bird.

Watch the groups of small birds that are pecking in the sand just above the wave line. How do they keep from getting wet? Does the group have a leader? What are they pecking at? Can you find out? Watch one member of a particular species of bird for ten minutes or so. Look for and record the following kinds of things about that bird: the kind of bird; how it holds its body when it walks (horizontal, upright, in between); its gait (hop, run, or waddle); grooming (does it groom its feathers? How?). Also note whether it raises its tail when it lands; whether it flies in a straight line, undulates (up and down), glides, soars, or flaps; and whether its wing beats are fast or slow. Does it get its feet wet, land on water, or land on bushes or trees?

Observe several kinds of birds in this way and make a chart of your records to show the differences and similarities among the birds you watched.



Bird Survey

Visit two or more types of coastal areas, such as a marsh and a rocky beach. What kinds of birds are found in each? Where are there more perching birds, wading birds, or swimmers? Identify as many of these birds as you can. Visit these places during more than one season. Do the kinds of birds present in each change with changing seasons?

Poke Pole Fish Survey

What kinds of fish live in rocky intertidal areas? You can find out what some of them are by going fishing with a poke pole. Make your poke pole from a 2-3 m (6-10 ft) p.e of bamboo or some other material. Tape about 30 cm (12 in.) of heavy wire with a size 2 or 4 fishhook on the end of the pole; 15 cm (about 6 in.) of wire is attached to the pole and 15 cm hangs out, with the hook on the end. File the barb from the hook so that you can easily release fish without damaging them. This kind of fishing should be done at low tide, but if there are large waves you should stay away from the edge of the water. Bait the hook with mussel, shrimp, or pieces of other marine animals. Fish by putting the pole into deep pools or crevices in the rock. Try many pools, keep a record of the kinds of fish you catch and where you caught them. You should be able to release most of your catch unharmed--unless of course you are very hungry.

What Kind of Organism Was It?

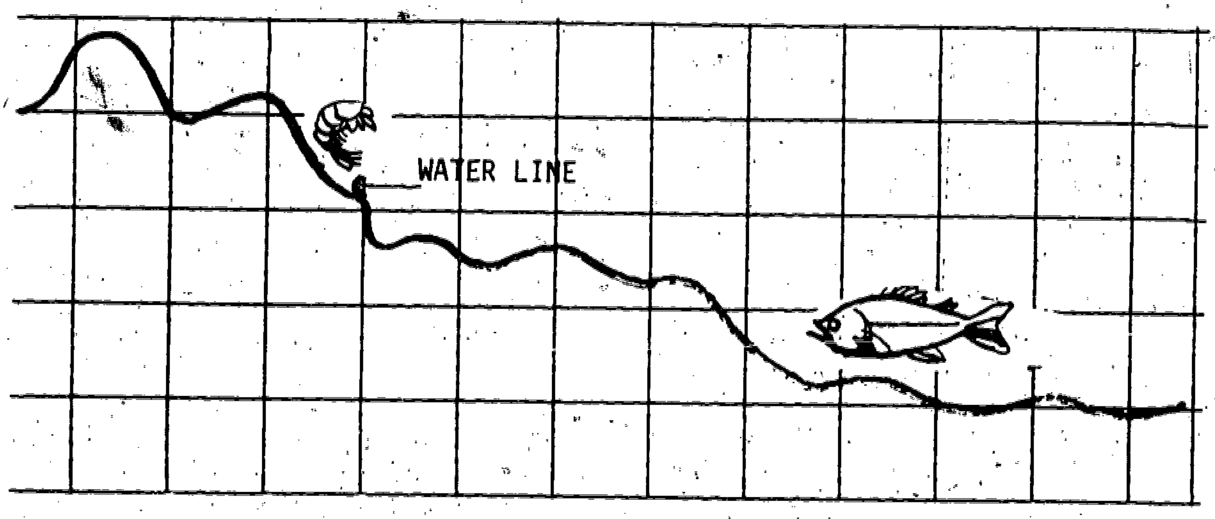
Walk along the beach soon after high tide. Make a collection of the fragments of what were once living things. Examine each fragment very carefully. Try to answer some of the following questions about each one: Was it a plant or animal? What did it look like when it was living? How big was it? Where did it live? How did it get to where you found it on your beach? Can you trace the path it took?

Life on a Rocky Beach

Visit the beach at low tide, and take with you pictures or descriptions of plants and animals that are commonly found in that area. What kinds of organisms are most common high up on the shore, but within the tidal zone--plants or animals? What kinds of organisms are most common in the lowest level exposed by the receding tide? How would you name these areas if you used the prevalent organisms to identify each zone? Which organisms are best adapted to live for the longest period of time in the air? Are there more water plants in the higher or the lower zone?

Aquatic Coastal Inhabitants

Several students should cooperate in this project. Any coastal area that is occupied by visible inhabitants is suitable. Select a length of coast that can be easily examined in the time available. Use graph paper to help you sketch the coast before you begin the survey. Each time you find an organism, observe and examine it. Record its description (in words and/or pictures) along with the depth of the water where you found it or its location on the beach.



Beach Hoppers

If you were a beach hopper how far could you hop? To find the answer to this question measure your length (height), the length of a beach hopper, and the distance a beach hopper hops. Substitute these data in this equation:

$$\frac{\text{your height}}{X} = \frac{\text{length of hopper}}{\text{distance hopper hops}}$$

Clams

If you live near a sand or mud flat in an estuary, you can dig clams. You will need a shovel or trowel and a bucket without a bottom. Go to the flats and find the likely places to look for clams in your area, using clam siphon holes as indicators of good places to dig. First jump or bang on the surface of the flat so the clams will draw in their siphons; this way you will be less likely to injure any of them. Dig around a siphon hole but not too close to it to avoid breaking the clam's shell. When your hole starts to cave in, put your bucket in it so that the siphon hole is near the center and the bucket is buried almost to the rim. Dig with your hands now. When you locate a clam, loosen it carefully before you attempt to lift it out. (You may wish to wear gloves to protect your hands from broken shells and glass.) Remember to rebury each clam in the hole from which you took it.

Now that you know and have followed the procedure for locating clams, see if you can answer the following questions:

- How far up the beach do clams live?
- Can you predict the size or kind of clam from the size of its siphon hole?
- Do little clams live closer to the surface than large ones?
- How many kinds of clams live in this tidal area?
- Do clams live alone or in groups?

Remember to put each clam back in the hole where you found it. Be careful to leave an air hole.

"Rubbing It In"

Many weathered objects on beaches have attractive and complicated patterns. Use plain paper and crayons or charcoal pencil to make rubbings from weathered boards or ends of pilings.

Coastal Classroom Ideas

In the classroom, put some brine shrimp eggs in fresh water and some in salt water and watch the containers for a few days. Where do you think brine shrimp might live? Watch under the microscope as your brine shrimp swim.

Make a trip to a nearby market. How many kinds of coastal organisms are for sale? How many people handled them before they reached the store?

In the classroom, put some sand and some soil in a glass container with water and stir the mixture. Let the sand and soil settle, then describe which layer is on top and which is on the bottom.

Collect mud and sand from a marsh, beach, or river. Put sand and mud in a glass container with water, mix it, and let it settle.

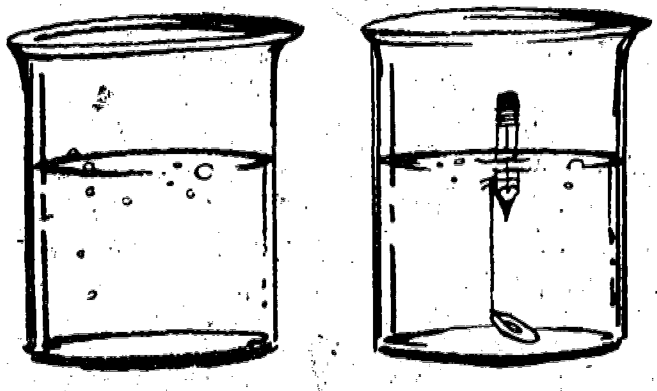
How many layers can you see? How are they different? What do you think causes this layering?

Carefully pour or siphon off the water. Examine a sample of each layer under the microscope. Describe and compare the particles. Are they dark or light, rough or smooth, sharp, thick or thin? How do mud particles differ from sand particles? Where do you think each might have originated? How do you think they got to where you collected them?

Make a Hydrometer

Take a stick (or pencil) and tie a weight such as a metal washer to one end, or screw a sharpened pencil into a metal nut. Place this "hydrometer" in a large container of fresh water. Mark the water line on the stick. Now repeat this experiment in a container of salt water. Is the water line on the stick different in salty and fresh water? What do you think causes the difference in the water line on the stick? Have a friend make a measured salt water solution. Now, try to guess the salinity of this solution.

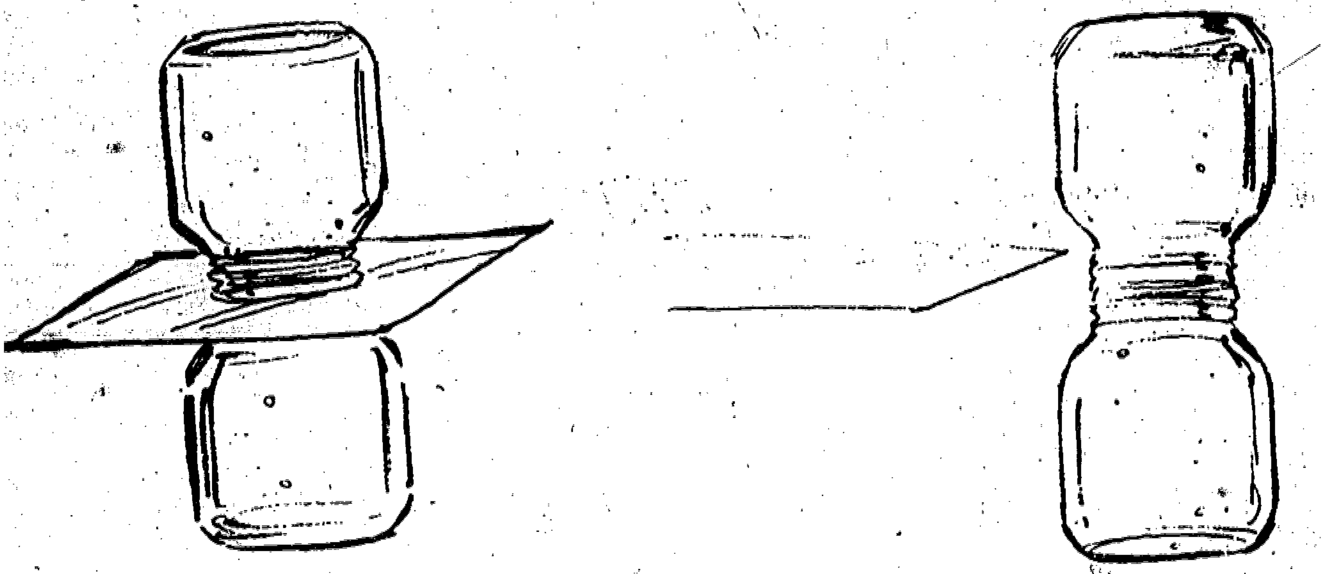
How could you mark (calibrate) your hydrometer for a solution that is one-third as salty as sea water? A solution one-half as salty?



Density of Water

Which is more dense, salt or fresh water? Completely fill two containers (such as baby food jars of the same size) with water. Do not place lids on the jars. To one jar, add a drop of food coloring and one half teaspoonful of salt. Mix well. Cover the top of the salt water container with a piece of cardboard. Invert the jar and place it directly over the top of the fresh water container so that the openings are aligned and separated only by the cardboard. Now, carefully slide out the cardboard. Observe and record the movements of the colored water. Repeat the experiment, this time putting the food coloring in the fresh water and placing the fresh water container on top of the salt water container. Try it sideways too.

What do you think happens when fresh river water flows into a salty ocean?



Salt in Rivers

To learn how to measure salinity in the classroom, carefully measure exactly 100 ml of sea water into a pyrex container. Weigh the container and the water. Evaporate the water. Now weigh the contents and the container again. Subtract your second measurement from the first. Multiply the difference in weight by ten (to adjust the volume from 100 ml to 1,000 ml). This will give the salinity of your sample in parts of salt per thousand parts of water (%).

Teachers with a marine aquarium can allow students to use the aquarium water as "seawater" if they cannot get to the ocean. Alternatively, several samples of salt water of various concentrations can be set up by the teachers, and the students can determine which one is closest in salinity to sea water.

Next, visit a salty river. How far up the river is the water salty? In the classroom, using a hydrometer (available at tropical fish stores), establish baseline readings for fresh water and for salt water (30% salt in water). Then, take a trip to a tidal river. Make a series of readings up the river from the ocean to see if you can find out how far up the river the water is salty. Consider the following questions:

- Does high or low tide make a difference in your readings?

- Can you tell when the water is one-half as salty as sea water?
- Does the depth at which you take the reading make a difference?
- How much of seawater is salt?

FURTHER RESOURCES

READING SUGGESTIONS*

ALL ABOUT THE SEA. Ferdinand C. Lane. Random House. 1953. Grades 5-6. 150 pages. Informational.

A general exploratory book about marine ecoystem. Tells how the sea began; briefly describes sea life; and concludes with an explanation of man's relationship to sea. Could be used as a listening exercise for lower intermediate children.

ALL KINDS OF SEALS. Bernice Kohn. Random House. 1968. Grades 5-6. 81 pages. Informational.

A descriptive book showing how seals changed from land to sea animals, their environment, and their relationships to man. Could be used as a reference book.

AMERICANS AND THE WORLD OF WATER. Harold L. Goodwin (ed.). University of Delaware Sea Grant College Program. 1977. Highly recommended!

ANIMALS OF THE SEA. Marcelle Verite. Childrens Press. 1964. Grades 4-8. 63 pages. Informational.

This brilliantly illustrated book is the American adaptation of the French book Animaux de la Mer. Each of the 25 sections describe a sea animal or group of marine animals. Sections on the Sargasso Sea, the Great Barrier Reef, and the Galapagos Islands are also included. Art work is by Romain Simon.

THE ART AND INDUSTRY OF SANDCASTLES. Jan Adkins. Walker Publishing Co. 1971. Grades 5-8 and all other readers. 29 pages. Informational.

Twenty-nine 11" x 15" hard-cover pages. This unique book cleverly combines the popular seaside occupation of sand castle building with the lives and times of ancient castle dwellers. The handsome monochrome illustrations show the sand castle builder and the how and why of castle construction; they help develop a vacabulary and a histroical perspective in the process. Thoroughly enjoyable.

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*Adapted from Project COAST, Language Arts Activities to Supplement Coast Learning Experiences (Learning Experience No. 5). One of a series of 86 learning experiences on Coastal and Oceanic Awareness available from Project COAST, 310 Willard Hall, University of Delaware, Newark, Delaware 19711.

THE BEACHCOMBER'S BOOK. Bernice Kohn. The Viking Press. 1970. Grades 4-8. 96 pages. Informational.

For the child who has access to the beach, this book offers suggestions for artistic and scientific activities. How to press seaweeds, how to make beach collages and mobiles are examples. Illustrations are by Arabelle Wheatley. There is an index, a bibliography, and a brief catalogue of Atlantic and Gulf Coast shells.

A BEACHCOMBER'S BOTANY. Loren C. Petry. Chatham Press. 1968. Grades 7-8. 158 pages. Informational.

A detailed account of flora and fauna of the New England Coast. Exquisite pencil drawings of plants and marine algae, with a descriptive account of each, make this a high-interest book.

THE BEACHCOMBER'S HANDBOOK OF SEAFOOD COOKERY. Hugh Zachary. John F. Blair, Publisher. 1969. For all readers. 208 pages. Informational.

More than a cookbook. This is a sincere commentary on seaside conservation. There's a recipe for just about any common marine animal including octopus. The line drawings are decorative. There is a serviceable index.

THE BEAVER POND. Alvin Tresselt. Lothrop, Lee & Shepard Co. 1970. Grades 1-6. 17 pages. Fiction.

Following the construction of a beaver dam, there is a complex and predictable succession of ecological events. This book tells the story of the history of a beaver pond and meadow. There are about 28 illustrations, most of which are in color.

A BOOK OF SNAILS. Sally Moffet Kellin. Wm. R. Scott, Inc. 1968. Grades 5-6. 48 pages. Informational.

A reference book about snails includes the snail's life cycle and instructions for keeping them as pets in terrariums. Reference is made to why snails may be considered as pests. Black-and-white photographs help to make this book a good selection for high-interest reluctant readers.

@ CAPE COD. Henry David Thoreau. W. W. Norton. 1951.

@ CANNERY ROW. John Steinbeck. Viking. 1945.

*THE CHALLENGE OF THE SEAFLOOR. Adelaide Field. Houghton Mifflin Co. 1970. Grades 7-12. 133 pages.

The story of the development of the submarine with particular emphasis given to the scientific research vessel, the Alvin. Traces the development of Alvin and details its journeys. Closes on an ecological regard for the presentation of the sea. A high interest book for the student interested in mechanical means of underwater exploration.

"CLIMATOLOGY AND WEATHER SERVICES OF THE ST. LAWRENCE SEAWAY AND GREAT LAKES." U.S. Weather Bureau. Technical Paper No. 35. 1959.

COASTAL ECOSYSTEMS MANAGEMENT: A TECHNICAL MANUAL FOR THE CONSERVATION OF COASTAL RESOURCES. John R. Clark. John Wiley & Sons. New York, New York. 1977. 928 pages.

*THE CURIOUS WORLD OF THE CRAB. Joseph J. Cook. Dodd, Mead & Co. 1970. Upper Middle School and others. 96 pages. Informational

Illustrated mostly by black-and-white photographs. There is a chapter on crabs in general as crustaceans and 39 pages describing various crabs of the world. One chapter is devoted to a non-crab, the horseshoe crab (Limulus), as a living fossil and there is a short discussion on crab mythology. The last chapter deals with crabs as seafood for people.

DIRECTORY OF SHIPWRECKS OF THE GREAT LAKES. Karl E. Heden. Bruce Humphries Publishers. Boston. 1966.

@ *THE EDGE OF THE SEA. Rachel L. Carson. Houghton Mifflin Co. 1955. Upper Middle School-High School. 251 pages. Informational.

The plant and animal life environments of the coral reef, sandy beach, and rocky coast are explored in this book. The author attempts to develop an appreciation of sea and surf. Accurate scientific insights are written in a literary style. Labeled pencil sketches of marine plants and animals make this a reference and guidebook for interested people.

EXPLORING NEW ENGLAND SHORES: A BEACHCOMBERS HANDBOOK. John F. Waters. Stone Wall Press, Inc. Lexington, Mass. 1974. 198 pages.

Provides information on coastline formation, shore ecology, crafts, aquariums, recipies and New England sea monsters.

CAPTAIN COOK. H. Bellis. McGraw-Hill Book Co. 1968. Grades 5-6. 60 pages. Biography.

A biography about the British explorer, Captain James Cook. Includes details about his voyages. Pencil drawings and maps are used for further explanation.

THE CHALLENGE OF THE SEAFLOOR. Adelaide Field. Houghton Mifflin Co. 1970. Grades 7-12. 133 pages. Informational.

The story of the development of the submarine with particular emphasis given to the scientific research vessel, the Alvin. Traces the development of Alvin and details its journeys. Closes on an ecological regard for the presentation of the sea. A high interest book for the student interested in mechanical means of underwater exploration.

THE CHANGEABLE WORLD OF THE OYSTER. Joseph J. Cook. Dodd, Mead & Co. 1974. Grades 7-8. 80 pages. Informational.

This is quite a thorough development of the subject including anatomy and reproduction, predators, disease and environmental problems. There are very interesting sections on the history, the culture and harvesting of oysters, and finally how to eat them. Bibliography, index and black-and-white photographs.

"CLIMATOLOGY AND WEATHER SERVICES OF THE ST. LAWRENCE SEAWAY AND GREAT LAKES." U. S. Weather Bureau. Technical Paper No. 35. 1959.

CREATURES OF THE DEEP. Agnes McCarthy. Prentice-Hall, Inc. 1963. Grades 5-6. 79 pages. Informational.

A book about various kinds of life in the sea. Some are familiar and all are intriguing. Much information about life in the sea is presented.

DIRECTORY OF SHIPWRECKS OF THE GREAT LAKES. Karl E. Heden. Bruce Humphries Publishers. Boston. 1966.

THE CURIOUS WORLD OF THE CRAB. Joseph J. Cook. Dodd, Mead & Co. 1970. Upper middle school and others. 96 pages. Informational.

Illustrated mostly by black-and-white photographs. There is a chapter on crabs in general as crustaceans and 39 pages describing various crabs of the world. One chapter is devoted to a non-crab, the horseshoe crab (Limulus), as a living fossil and there is a short discussion on crab mythology. The last chapter deals with crabs as seafood for people.

DEEP-SEA WORLD: THE STORY OF OCEANOGRAPHY. Charles Coombs. William Morrow & Co. 1966. Upper Intermediate Middle School. 251 pages. Informational.

Tells about the ocean and man's uses and abuses of it. Begins with how the oceans were formed and presents all the aspects of the sea. Terminology related to the study of oceanography is explained in context, indicating this book would be of value to a student with high interest in this area. Charts and photographs are numerous.

DISCOVERING THE AMERICAN STORK. Jack Denton Scott and Ozzie Sweet. Harcourt, Brace and Jovanovich, Inc. 1976. Upper Intermediate. 64 pages. Infomational.

A factual account of the life of the American stork, a recently discovered species. Myths about the stork are also explained. The flourishing of the species in modern times is researched for the reader. The book would be valuable to someone with high interest or as a reference book about the American stork. Presents unique qualities of American wood stork and discusses efforts to preserve the species in Florida." Black-and-white photographs.

THE EDGE OF THE SEA. Rachel L. Carson. Houghton Mifflin Co. 1955. Upper Middle School-High School. 251 pages. Informational.

The plant and animal life environments of the coral reef, sandy beach, and rocky coast are explored in this book. The author attempts to develop an appreciation of sea and surf. Accurate scientific insights are written in a literary style. Labeled pencil sketches of marine plants and animals make this a reference and guidebook for interested people.

ELISABETH AND THE MARSH MYSTERY. Felice Holman. The Macmillan Co. 1966. Lower Intermediate. 49 pages. Fiction.

A mystery story that offers information as well as intrigue. Elisabeth and a friend try to identify strange calls from the marsh. In doing this they learn about bird migration. The facts in this book do not seem dull because humor is maintained through story-telling.

ELISABETH, THE TREASURE HUNTER. Felice Holman. The Macmillan Co. 1964. Lower Intermediate. 42 pages. Fiction.

A story about Elisabeth, Papa, and a friend who are looking for hidden treasure. The person who hid the treasure gave them clues. In trying to follow the clues, they discover life on the shore. The plot of the story overshadows information about marine life in this story.

EXPLORERS OF THE DEEP. Donald W. Cox. Hammond, Inc. 1968. Middle School. 93 pages. Biography.

This book tells the stories of eighteen men who have made contributions to the study of the sea. It begins with Benjamin Franklin and concludes with contemporary oceanographer Roger Revelle. A chapter is devoted to future technological explorations of the ocean.

EXPLORING A BROOK: LIFE IN THE RUNNING WATER. Winifred and Cecil Lubell. Parents Magazine Press. 1975. Lower Intermediate. 61 pages. Informational.

A one- or two-page explanation of the various kinds of plant and animal life found in and near a brook. Pencil sketches illustrate each description.

EXPLORING AND UNDERSTANDING OCEANOGRAPHY. Anabel Dean. Benefic Press. 1970. Lower and Upper Intermediate. 96 pages. Informational.

A question-and-answer format is used to explain the fundamentals of oceanography. It begins with a description of the planet Earth; tells about currents, waves, and tides; and concludes with a discussion of underwater exploration and treasures from the sea. Each chapter concludes with questions and simple experiments. A resource book that would be of value for a learning experience about oceanography.

FAMOUS SMALL BOAT VOYAGES. Walter Buehr. G. P. Putnam's Sons. 1966. Grades 4-6. 128 pages. Informational.

Discusses the preparations and adventures of the crews of nine small boats on long and hazardous voyages. Included are tales of the first Atlantic crossing by a lone woman, the first Atlantic crossing in a rowboat, and the first single-handed cruise around the world. Illustrated with two-color sketches.

A FIELD GUIDE TO THE SHELLS OF OUR ATLANTIC AND GULF COASTS. Percy A. Morris. Houghton Mifflin Co. 1951. Middle School-High School. 228 pages. Informational.

Primarily an identification guide to over 500 kinds of shells. Also tells about the life-styles of many sea animals. Provides information about emptying shells, recording finds, and classifying and associating different kinds of shells.

FINS AND TAILS: A STORY OF STRANGE FISH. Elizabeth A. Campbell. Little, Brown & Co. 1963. Lower Intermediate. 58 pages. Informational.

A story about different kinds of fish found in the oceans. Using analogies (e.g., swimming balloon for puffer), the author describes some varieties of strange fish in simple sentences. Pictures accompany each description.

THE FIRST BOOK OF THE OCEAN. Sam and Beryl Epstein. Franklin Watts, Inc. 1961. Upper Intermediate. 70 pages. Informational.

An exploratory book about oceans including tides, waves, currents, the ocean floor, continental shelves, and slopes. Life in the ocean is discussed and future hopes for the world in the ocean are noted. Illustrated with sketches.

THE FIRST BOOK OF THE SEASHORE. Wyatt Blassingame. Franklin Watts, Inc. 1964. Upper Intermediate. 58 pages. Informational.

A description of the seashores of the world. Tells about the plant and animal life found there and the processes that affect it. The author attempts to impart understanding of things seen at the seashore. Pencil sketches illustrate some of the forms of plant and animal life.

FISHES. Loren P. Woods. Follett Publishing Co. 1969. Grades 3-6. 32 pages. Informational.

This excellent book on fishes discusses their evolution, distribution, and ecology. The book is enhanced by Tom Dolan's brilliant color illustrations. The sections on coral reef fishes, deep-sea fishes, and fishes of the West Indies are particularly well done.

FISHES. Herbert S. Zim and Hurst H. Shoemaker. The Golden Press. 1955. Middle School and others. 160 pages. Informational.

For the identification of the common fresh and salt water fishes of North America. Species are identified by color pictures. Common and scientific names are given. Useful guide for beginners.

FISHES OF THE GREAT LAKES REGION. Carl Hubbs and Karl Lagler. Bulletin 26 (rev.). Bloomfield Hills, Michigan. Cranbrook Institute of Science. 1958.

FISHING FOR TUNA. Lewis Allison. Melmont Publishers, Inc. 1957. Lower Middle School. 35 pages. Informational.

The ships, nets, and procedures of catching tuna are well described. Good monochrome illustrations of tuna and tuna fishing.

FRESHWATER FURY YARNS AND REMINISCENCES OF THE GREATEST STORM IN INLAND NAVIGATION. Frank Barcus. Wayne State University Press, Detroit. 1960.

FOUR WALRUSES FROM ARCTIC TO OCEANARIUM. Lou Jacobs, Jr. Wm. R. Scott, Inc. 1968. Grades 7 and up. 62 pages. Informational.

A factual account of the development of four walruses captured in Alaska and raised in California. Actual photographs of the walruses all during development are included. The author speaks of the walruses with affection and describes each one as an individual with unique personality traits. A unique book.

FRESH WATER FROM SALTY SEAS. David O. Woodbury. Dodd, Mead & Co. 1967. Grades 6-12. 96 pages. Informational.

All of the industrial methods of desalination that show promise are reviewed. Some of the technical passages may require studied reading. The book is indexed and contains about 35 photographs and drawings. David O. Woodbury is the author of more than 31 science books for children.

THE FRIENDLY DOLPHINS. Patricia Lauber. Random House. 1963. Grades 4-6. 79 pages. Informational.

Many different aspects of the dolphin are covered: the history of the dolphin as a friend of man; its physical make-up and similarities to other species; and its unique sonar talents. Photographs and sketches are included.

GEOLOGY OF THE GREAT LAKES. Jack L. Hough. Urbana, Illinois. University of Illinois Press. 1958.

GREAT LAKES COUNTRY. Russell McKee. New York, New York. Thomas Y. Crowell Co. 1966.

THE GREAT LAKES READER. Walter Havighurst. New York, New York. The Macmillan Company. 1966.

THE GLACIAL LAKES SURROUNDING MICHIGAN. Robert W. Kelly. Lansing, Michigan. Michigan Department of Conservation. December 1960.

GREAT SEA POETRY. Willard Bascom, ed. Compass Publications, Inc. 1969. Upper Middle-High School. 119 pages. Poetry.

Includes poems by Rudyard Kipling, A. A. Milne, John Masefield, Lewis Carroll, Matthew Arnold, Robert Browning, Oliver Wendell Holmes, Sir William Gilbert, John Gray, and J. Frank Stimson. The poetic nature of the sea becomes evident as one reads the descriptive emotion-filled lines. A glossary of special words and a gazetteer of places (listed by poem) is included.

THE GREAT WHALES. Herbert S. Zim. William Morrow & Co. 1951. Grades 3-6. Informational.

An extremely detailed description of the physiology of the whale. Different species and habits of whales are discussed and depicted by black-and-white drawings. Large print would probably make this book appealing to young whale enthusiasts.

GULLS. Sarel Eimerl. Simon and Schuster. 1969. Grades 4-8. 64 pages. Informational.

Nature writer Sarel Eimerl describes various members of the gull family, their feeding and hunting habits, and their migratory and courtship behavior. Illustrated with 30 black-and-white photographs. Index included.

HALIC: THE STORY OF A GRAY SEAL. Ewan Clarkson. E. P. Dutton & Co. 1970. Upper Middle School. 158 pages. Fiction.

The author's excellent literary skills are evident by the realistic descriptions in this fascinating story of the life of Halic, a gray seal. Several appropriate illustrations make the natural setting even more convincing.

HARVESTING THE SEA. D. X. Fenten. J. B. Lippincott Co. 1970. Grades 4 and up. 58 pages. Informational.

A good reference for learning about the riches found in the sea (plants, animals, and minerals) and careers related to the harvesting of these riches. Photographs and sketches are good.

HIGH WATER AT CATFISH BEND. Ben Lucien Burman. Puffin Books. 1974. Grades 4 and up. 123 pages. Fiction.

Enchanting story of five animals who realize they must forget their personal problems and work together. Their home is the Mississippi flood plains and they are disgusted with the way humans are controlling floods. They unite to do something about it.

HOMES BENEATH THE SEA: AN INTRODUCTION TO OCEAN ECOLOGY. Boris Arnov, Jr. Little, Brown & Co. 1969. Grades 7-9. 131 pages. Informational.

Each of the chapters deals with a different habitat in and near the sea: seashore, continental shelf, open sea, coral reef, and the high seas. The book contains well written passages but it suffers from poor organization. A book of this sort should have a bibliography; this one doesn't. The photographs are good.

HORSESHOE CRAB. Robert M. McClung. William Morrow & Co. 1967. Lower Intermediate. 48 pages. Fiction.

Describes the life cycle of the horseshoe crab, an animal that is a common sight along the Atlantic coastline. Also describes the parts of the horseshoe crab one can observe at the beach. Black-and-white sketches illustrate and add much detail to the text.

HOW TO KNOW THE AMERICAN MARINE SHELLS. R. Tucker Abbott. The New American Library. 1961. Grades 7 and up. 222 pages. Informational.

Abbott divides his reference book into two parts. In his Natural History section he discusses the mechanics of having shells as a hobby--collecting and cleaning shells, and organizing shell collecting clubs. In the Identification section he describes each type of shell in great detail and refers the reader to color plates included.

IN THE DEEP BLUE SEA. Elizabeth Morgan. Prentice-Hall, Inc. 1962. Upper Intermediate-Middle School. 70 pages. Informational.

An account of the sea--its explorations, ocean mining, oil-drilling, harvesting of ocean crops, and fossils of the deep. The book also includes simple explanations of some jobs which can be found involving working under the sea. A beginning study of oceanography. Acquaints reader with the past and present research, underwater archaeology, biology, and the importance of the sea for the future.

ISLAND OF THE BLUE DOLPHINS. Scott O'Dell. Houghton Mifflin Co. 1960. Grades 6 and up. 184 pages. Historical Fiction.

An account of a young native girl's life alone on the "Island of the Blue Dolphins." This fascinating tale is based on facts recorded by ship captains that actually knew the girl. A must for adventure lovers.

JOHN TABOR'S RIDE. Blair Lent. Atlantic Monthly Press. 1966. Lower Intermediate. 48 pages. Fiction.

A tall tale about a shipwrecked man named John Tabor who hitches a ride on a whale from the South Seas to his home in Nantucket. He has a traveling companion and together they have an encounter with Neptune. Detailed illustrations add interest to the story.

LAKE ERIE. Harlan Hatcher. Bobbs Merrill Company. New York.

LAKE HURON. Fred Landon. Bobbs Merrill Company. New York.

LAKE MICHIGAN. Milo M. Quaife. Bobbs Merrill Company. New York.

LAKE ONTARIO. Arthur Pond. Bobbs Merrill Company. New York.

LAKE SUPERIOR. Grace Lee Nute. Bobbs Merrill Company. New York.

LANDS ADRIFT: THE STORY OF CONTINENTAL DRIFT. Malcolm Weiss. Parents Magazine Press. 1975. Grades 4-6. 63 pages. Informational.

A readable and enjoyable discussion of how land has drifted and changed over millions of years. Also presents historical hypotheses of how this occurs.

THE LAST FREE BIRD. Harris A. Stone. Prentice-Hall, Inc. 1967. All grades. Fiction.

A plea to save our environment is made in this picture book for all ages. Beautiful water color illustrations.

LET'S EXPLORE A TIDE POOL. Bruce E. Tatje and Mark A. Weise. Science Dept., Martin County High School, Stuart, FL. 1971. Grades 2 and up. 39 pages.

A clear, concise guidebook for exploring a tide pool. The environment and the organisms found in it are described and often sketched. An asset to a group of young marine biologists.

LET'S GO ON A TURTLE WATCH. Diana Hart and Larry Crary. Martin County High School, Stuart, FL. 1970. Grades 3 and up. Informational.

A well presented field guide for young children interested in turtles and their habitats. Bibliography included.

LIFE IN PONDS. Jean Gorvett. American Heritage Press. 1970. Middle School and up. 31 pages. Informational.

An introduction to the living things in a pond and how to fish and observe them. The common plants of freshwater ponds are attractively and accurately illustrated in color and very briefly discussed (about one page). There is one page on the smaller invertebrates, three nicely illustrated pages on mollusks, and an appealing eight-page section on insects. The reptiles are accorded one page, the amphibians three, fishes one, birds two, and mammals (the muskrat) one. The remaining five pages are divided into sections on worms, scavengers, parasites, aquariums, and record keeping. There is no bibliography or index.

LIFE IN THE SEA. Gwynne Vevers. McGraw-Hill Book Co. 1965. Lower and Upper Intermediate. 42 pages. Informational.

An informative, handsomely illustrated book about forms of sea life. The author attempts to impart understanding of what the sea is like and how it is explored.

THE LIFE OF SEA ISLANDS. N. J. and Michael Berrill. McGraw-Hill Book Co. 1969. Grades 3 and up. 231 pages. Informational.

A very complete reference that discusses many islands and their origins, wildlife, and importance. Outstanding photographs and illustrations. A top-notch reference.

THE LIFE OF THE MARSH. William A. Niering. McGraw-Hill Book Co. 1966. Grades 6-12. 232 pages.

Maintains the high standards of the books in this series. One section describes the distribution of the eight types of wetlands in the United States. Another section describes the energy flow through wetland ecosystems. Contains about 200 illustrations, many in color. A glossary, appendices, a bibliography, and an index are included.

THE LIFE OF THE OCEAN. N. J. Berrill. McGraw-Hill Book Co. 1966. Grades 6-12. 232 pages. Informational.

Discusses the wide variety of plants and animals found in different parts of the ocean. Beautifully illustrated with many photographs, many of which are in color. The appendix includes a section on starting and maintaining a marine aquarium. A glossary, bibliography, and index are also included.

THE LIFE OF THE SEASHORE. William H. Amos. McGraw-Hill Book Co. 1966. Grades 7-12. 231 pages.

Describes the diverse kinds of marine shore life to be found in and around sandy beaches, tidal flats, rocky cliffs, etc. Richly illustrated in vivid color, including many of the author's photomicrographs. The book, like others in the series, describes life in terms of ecological patterns and relationships. There are five appendices, a glossary, a bibliography, and an index.

LITTLE CALF, adapted from YEAR OF THE WHALE. Victor B. Scheffer. Charles Scribner's Sons. 1970. Upper Intermediate. 140 pages. Fiction.

This is the fictionalized, but biologically accurate story of a young sperm whale during his first year of life. Illustrated.

THE LIVING SEA. Ritchard Read. Penguin Books, Inc. Middle School and up. 48 pages. Informational.

Very briefly introduces the organisms of the sea. Some are nicely illustrated in full color, including plankton, seaweeds, mollusks, crustaceans, fishes, and mammals. Very brief attention is given to vertical migration, food chains, food pyramids, geography, and evolution. There is a list of oceanographic expeditions, a list of suggested readings, and a one-page index. No. 11 of the Explorer Series. Paper cover.

LOBSTERMAN. Dahlov Ipcar. Alfred A. Knopf, Inc. 1962. Grades 4 and up. 38 pages. Fiction.

Color paintings profusely illustrate the work of the lobsterman, his clothing, his boat, the traps, and the lobsters. A boy helps prepare the boat and equipment and finally enjoys a lobster dinner.

LOG TRANSPORTATION IN THE LAKE STATES. W. G. Rector. Glendale, California. A. H. Clark Company. 1953.

THE LONG SHIPS PASSING. Walter Havighurst. New York, New York. The Macmillan Company. 1942.

THE LONG VOYAGE. THE LIFE CYCLE OF A GREEN TURTLE. Alvin and Virginia Silverstein. Frederick Warne & Co. 1972. Middle School and others. 48 pages. Fiction.

The life cycle of the green sea turtle is traced by a team of scientists and a young boy on a long, hazardous journey across hundreds of miles of open ocean. A glimmer of insight into marine research and the balance of nature may be achieved.

LORE OF THE LAKES. Dana Thomas Bowen, Cleveland, Ohio. The Lakeside Printing Company. 1948.

MAGIC OF THE SEA. Max Albert Wyss. The Viking Press. 1968. All ages. 86 pages. Informational.

Superb photographs of the sea and its inhabitants are combined with essay and poems to make a moving essay about people and the sea. The influence of the oceans on human cultures is impressively developed. A handsome book.

MAN EXPLORES THE SEA. Malcolm E. Weiss. Julian Messner. 1969. Upper Middle School and others. 110 pages. Informational.

The story of the three Sealab expeditions in which man lived for many days at the bottom of the sea and of other explorations of the ocean depths. Illustrated with black-and-white photographs. Glossary and index.

A MAP IS A PICTURE. Barbara Rinkoff. Thomas Y. Crowell Co. 1965. Upper Elementary School and others. 35 pages. Informational.

Various kinds of maps and charts and their symbols are introduced. This brief experience could lead to many educational experiences.

MARSHES AND MARSH LIFE. Arnold Dobrin. Coward-McCann. 1969. Grades 4-8. 47 pages. Informational.

The author successfully describes marsh life in terms of the effects that seasonal changes and tidal fluctuations have on the marsh's inhabitants. The well written book is illustrated with the author's brilliant watercolors. A strong case is made for marsh conservation.

MEET THE MEN WHO SAILED THE SEA. John Dyment. Random House. 1966. Lower Middle School. 85 pages.

A historical treatment of sailing craft and sailors from log canoes and reed boats to clipper ships. It ends with a brief account of Slocum's solo voyage around the world in 1895. Famous mariners included Eric the Red, Marco Polo, Magellan, Cook, and Francis Drake. Nicely illustrated with monochrome drawings.

MISS PICKERELL GOES UNDERSEA. Ellen MacGregor. McGraw-Hill Book Co. 1953. Grades 4-8. 125 pages. Fiction.

What a fun way to learn about sonar, atomic-powered submarines, and under-the-sea salvaging. The always unpredictable Miss Pickerell must use these things in the recovery of her priceless Mars rocks that were being transported on a ship that sank.

THE MYSTERY OF THE RED TIDE. Frank Bonham. E. P. Dutton & Co. 1966. Upper Intermediate. 128 pages.

Exciting tide-pool exploring on the Pacific Coast along with solving a mystery make for an exciting summer for Jill and her newly arrived cousin Tommy from Kentucky.

NETS OVERBOARD! Jack Coggins. Dodd, Mead & Co. 1965. Grades 6 and up. 96 pages. Informational.

An account of the methods used in the fishing industry. Oceanography and life in the sea are also discussed. Many supporting pictures and captions.

THE OCEAN WORLD. Peter Ryan. Penguin Books, Inc. 1973. Grades 7 and up. 48 pages. Informational.

The ocean itself and almost everything that affects it is covered by Ryan's short but informative book. A bit of history of the exploration of the undersea world is presented including pictures of an early diving bell and undersea saucers. A good introduction to the ocean's wealthy potential--oil, minerals, and hydroelectric power.

OCTOPUS LIVES IN THE OCEAN. William and Peggy Stephens. Holiday House. 1968. Middle School. 47 pages.

Does a good job of describing the life of an Atlantic octopus for young readers. The book is well illustrated mostly in black-and-white, and the common neighbors of the octopus are introduced in interesting accounts of day-to-day events.

OF MEN AND MARSHES. Paul L. Errington. The Iowa State University Press. 1957. Grades 8-12. 150 pages.

This is a book of memories and philosophy by a man who rose from fur trapper to college professor. It describes marshes all over America, but dwells on the glaciated prairie marshes of the Dakotas. The 23 illustrations are excellent but do not have captions. There is no index. The author's knowledge of marsh ecology makes this a very worthwhile book.

PAGOO. Holling Clancy Holling. Houghton Mifflin Co. 1957. Grades 3-9. 87 pages. Fiction.

This book tells the story of Pagoo, a hermit crab, from larvation to maturity. Life in the tidal pool is not easy. There is a chronic housing shortage. Risks are incurred in the love-making adventure. This complete book has 20 full-page color drawings and numerous marginal illustrations.

PENGUINS: THE BIRDS WITH FLIPPERS. Elizabeth S. Austin. Random House. 1968. Middle School. 84 pages. Informational.

Authoritative book about the lives of various species of penguins with good black-and-white photographs and a history of penguin naturalists. An index.

PIONEERS OF EARLY WATERWAYS. Edith McCall. Childrens Press. 1961. Middle School. 127 pages. Biography.

A collection of stories about early Americans on the canals and rivers. Includes stories about Davy Crockett, Mike Fink, and Mark Twain. A steamboat race is the climax.

POND LIFE: A GUIDE TO COMMON PLANTS AND ANIMALS OF NORTH AMERICAN PONDS AND LAKES. George K. Reid. Golden Press. 1967. Middle School and others. 160 pages. Informational.

Mostly a very usable manual for identification of a wide variety of common plants and animals of fresh water ponds, including birds and mammals. There is a very brief treatment of the physical features of a pond and of aquatic ecosystems, and a bibliography and five-page index. Useful for amateur pond watchers of all ages.

QUESTIONS ABOUT THE OCEANS. Harold Dubach and Robert Taber. U.S. Government Printing Office. Grades 3 and up. 121 pages. Informational.

Look up the question you want answered in the table of contents, turn to the page on which that question appears, and there you have it. One hundred questions are answered. Relevant diagrams and sketches are included. Simple, easy-to-use reference book.

QUESTIONS AND ANSWERS ABOUT SEASHORE LIFE. Ilka Katharine List. Four Winds Press. 1970. Upper Intermediate. 123 pages. Informational.

Excellent book. Uses a question-and-answer format to discuss the animals found near rocky, sandy, and muddy shores. Well illustrated.

THE QUEST OF CAPTAIN COOK. Millicent E. Selsam. Doubleday & Co. 1962. Grades 6 and up. 126 pages. Informational.

James Cook's efforts to explore uncharted oceans and lands come to life in this book. His travels took him around the world and resulted in the discovery of many new lands. Simple, yet effective illustrations.

THE REMARKABLE DOLPHIN. Henry Chapin. Young Scott Books. 1962. Upper Intermediate. 92 pages. Informational.

An informational book about the life-style and life cycle of the dolphin. It gives specific information about the *Tursiops truncatus*, the dolphin that is familiar along the Atlantic Coast. The author explains the Tursiops' behavior, intelligence, and physiology. Illustrated with black-and-white drawings.

THE RISE AND FALL OF THE SEAS: THE STORY OF TIDES. Ruth Brindze. Harcourt, Brace & World, Inc. 1964. Upper Intermediate-Middle School. 91 pages. Informational.

Good introduction to causes and effects, and dangers and uses of tides. Illustrated with black-and-white photographs and diagrams.

RIVERS. Delia Goetz. William Morrow & Company. 1969. Intermediate. 63 pages. Informational.

An exploratory book about the rivers of the world. What has been learned about them through history is discussed as well as how they are formed. Some famous rivers are also mentioned and the need for river conservation and water pollution controls is pointed out. Black-and-white drawings illustrate this book.

THE ROCKY SHORE. John M. Kingsbury. The Chatham Press, Inc. 1970. Grades 7 and up. 77 pages. Informational.

The physical characteristics and land and sea flora and fauna of the New England Coast are described in great detail. The original state, subsequent development, and present state of the coastline are also depicted by excellent black-and-white sketches. An index of plant, animal, and rock types is included. May also serve as a practical field guide.

THE ROPE'S END. Reginald B. Hegarty. Houghton Mifflin Co. 1965. Grades 5 and up. 131 pages. Fiction.

At the age of 12, Hegarty made his first whaling voyage as a part of the crew on his father's ship. Life on a sailing vessel is not easy for such a mischievous boy. Amusingly, his actions frequently result in a meeting of the seat of his pants with a "rope's end." Exciting, charming, convincing.

SCIENCE SHIP: A VOYAGE ABOARD THE DISCOVERER. Peter Briggs. Simon & Schuster. 1969. Grades 7 and up. 128 pages. Informational.

The author fills us in on what he learned day by day aboard the Discoverer, a highly complex and sophisticated vessel designed to explore the sea in great detail. Photographs and captions are helpful.

SEA AND SHORE. Clarence J. Hylander. The Macmillan Co. 1950. Upper Intermediate-Middle School. 242 pages. Informational.

Very readable story of plants and animals that live on the shore. Seaweeds, mollusks, crustaceans, jellyfish, univalves, starfish, sand dollars, and sea urchins are among the forms of life described. The physical features of the ocean environment and how the organisms have adapted are also discussed. Illustrated with black-and-white photographs and diagrams.

THE SEA AROUND US. Rachel Carson. Franklin Watts. 1961. Golden Press. 1951. Grades 8-12. 259 pages. Informational.

Miss Carson's famous book is the winner of many accolades, including the National Book Award. In the book she describes the sea in three different ways: the mother sea, the restless sea, and the sea's relationship with man, i.e., man and the sea about him. The book conveys knowledge of the sea in a language that often rises to poetic elegance.

SEABIRD. Holling Clancy Holling. Houghton Mifflin Co. 1948. Upper Intermediate. 60 pages. Fiction.

The story of an ivory carved gull created by a man on a whaling boat. The adventures of the gull, Seabird, as it passes through four generations of its creator, form the story. Scenes of the development of crafts of the sea, and finally air transportation, take the reader on a journey through America's past. Full-page color illustrations and pencil drawings along margin enhance the story.

SEA CAREERS. D. X. Fenten. J. B. Lippincott Co. 1970. Grades 4 and up. 162 pages. Informational.

An extensive listing of jobs related to the sea. Descriptions, qualifications, schooling, suggested salaries (now outdated), addresses of some sources for information and applications, and an index are included.

THE SEA EGG. Lucy M. Boston. Harcourt, Brace & World. 1967. Upper Intermediate. 94 pages. Fiction.

A story about two young brothers and their magical summer at the beach. After purchasing an unusual egg-shaped rock, they hide it in a pool of sea water and wait for it to hatch. The boys' adventures with what hatches weave this sea tale.

SEAHORSES. Lilo Hess. Charles Scribner's Sons. 1966. Lower Intermediate. 46 pages. Informational.

This book is about the life cycle of the sea horse. The physiology of the animal is discussed as well as others of its family in the marine environment. Directions for making an aquarium for sea horses are given. Black-and-white photographs are used throughout the book.

SEALS. K. M. Backhouse. Golden Press. 1969. Grades 8 and up. 96 pages. Informational.

Photographs (color and black-and-white) of seals in their natural habitats help make this such an impressive reference. The author initially describes many types of seals and later concentrates on Grey seal and its life-style.

SEA SHELLS OF THE WORLD. R. Tucker Abbott. Golden Press. 1962. Upper Intermediate and up. 162 pages. Informational.

Outstanding pocket handbook. Comprehensive and well illustrated. Uses both common and scientific names.

SEASHORES: A GUIDE TO ANIMALS AND PLANTS ALONG THE BEACHES. Herbert S. Zim and Lester Ingle. Golden Press. 1955. Grades 5-12. 160 pages. Informational.

About 460 forms of seashore life are described and illustrated in this book. It is attractive and authoritative. Its convenient hip-pocket size makes it a useful companion for anyone who frequents the beaches. There is an index with a list of scientific names of the plants and animals discussed.

SEE ALONG THE SHORE. Millicent Selsam. Harper & Row Publishers. 1961. Lower Intermediate. Informational.

Discusses some of the things children might wonder about as they walk along the beach: why the sea is salty; the formation of sand and dunes; sea shells and animals on the beach; tides and what causes them; and animal tracks in the sand. Also discusses the intertidal zone and insects found near the shore. Colorful illustrations show what is being described.

SEE THROUGH THE LAKE. Millicent Selsam. Harper & Row Publishers. 1958. Lower Intermediate. 48 pages. Informational.

An explanation of lakes--how they were formed, what types of life they support, and the effect of the land around them. A description of specific types of life found at different levels of water is included. Pictures showing clearly what the author is discussing aid in understanding for the young reader.

SEE THROUGH THE SEA. Millicent Selsam and Betty Morrow. Harper & Row Publishers. 1955. Lower Intermediate. Informational.

A story about a journey into the depths of the sea and what things a person might see there. Animal and plant life at different depths are explored. The author uses a round insert diagram on every page to help show exactly what part of the sea is being explained.

SHIPS THAT NEVER DIE. Marine Historical Society of Detroit. Detroit, Michigan. 1952

SHIPWRECKS OF THE LAKES. Dana Thomas Bowen. The Lakeside Publishing Company. Cleveland, Ohio. 1952.

"SOME SEA TERMS IN LAND SPEECH." Samuel F. Batchelder. The New England Quarterly (January-October). 1929. pp. 625-653.

SPRING COMES TO THE OCEAN. Jean Craighead George. Thomas Y. Crowell Co. 1965. Upper Middle School and others. 110 pages. Fiction.

The book consists of a series of well written accounts of various marine animals as spring approaches. Included are the hermit crab, turtle, man-of-war, octopus, porpoise, oyster, starfish, fishes, and some of the lower invertebrates. It ends with a chapter on the gray whale. Good reading. Sparsely illustrated with black-and-white drawings.

STARFISH. Edith Thacher Hurd. Thomas Y. Crowell Co. 1965. 35 pages. Informational.

A delightful introduction to the starfish. Its life-style and beauty are described with carefully chosen words. Fascinating illustrations give the reader a feeling of being near the sea.

STRANGE FISHES OF THE SEA. Olive L. Earle. William Morrow & Co. 1968. Lower Intermediate. 63 pages. Informational.

An informational book about some creatures who live in the sea and who are thought to have strange shapes and habits. Compares sea and land animals, such as sea snakes and land snakes. Black-and-white pencil drawings illustrate this book.

THE SUNLIT SEA. Augusta Goldin. Thomas Y. Crowell Co. Lower Intermediate. 33 pages. Informational.

An introductory book about the ecosystem of the undersea world as far down as sunlight penetrates (about 200 feet). Plant and animal life found at this level are described. Drawings done in three colors illustrate this book.

SURF'S UP! Arthur H. Klein and M. C. Klein. The Bobbs-Merrill Co. 1966. Upper Middle School and others. 224 pages.

A collection of 79 photographs and stories, cartoons, poems, and anecdotes about surfing. Great reading for devotees of the sport.

SWAN OF THE EAST. Edwin P. Hoyt. The Macmillan Co. 1968. Upper Middle School and others. 200 pages. Informational.

An account of the crew of the German cruiser Emden in World War I (1914) as they harrassed allied shipping in Pacific Ocean. After the Emden was sunk, they made their way to Constantinople and their allies. One of the great epics of naval warfare. Good reading.

TARO AND THE SEA TURTLES. Arnold Dobrin. Coward, McCann & Geoghegan. 1966. Lower Intermediate. Fiction.

A Japanese tale about a young boy who dreams of buying gold to gild the Buddha in the village. The realization of his dreams and his adventure to the island to purchase the gold are the focus of the story. Taro's kindness to the sea turtles is reciprocated in an exciting way. Illustrated with black-and-white drawings.

THREE BOYS AND A LIGHTHOUSE. Nan Hayden Agle and Ellen Wilson. Charles Scribner's Sons. 1951. Lower Middle School. 100 pages. Fiction.

A good story with a few black-and-white illustrations about the adventures of three boys who spend a summer helping to tend a lighthouse.

TIM TO THE RESCUE. Edward Adrizzone. Henry Z. Walck, Inc. 1949. Lower Intermediate. Fiction.

A story about three boys who are part of the crew of a ship. Tim and Ginger develop a friendship and begin many adventures on the ship. Ginger's problems with his hair, and a hurricane are the major problems. Watercolor drawings illustrate this book.

TO THE BRINK OF EXTINCTION. Edward R. Ricciuti. Harper & Row Publishers. 1974. Grades 6 and up. 169 pages. Informational.

The stories of seven animals threatened with extinction are told: the Puerto Rican Parrot, the shaggy European Bison, Pere David's Deer, the Pine Barrens Tree Frog, the Bog Turtle, the Osprey, and the Gray Whale. The complexities and morality of saving living things from extinction are discussed. There is an index and very short bibliography. The illustrations are poor.

TRACKS BETWEEN THE TIDES. Elizabeth Shepherd. Lothrop, Lee & Shepard. 1972. Upper Intermediate. Informational.

Discusses how to locate, dig up, and observe burrowing animals of the intertidal zone. Diagrams illustrate the variety of life forms that can be found.

TROPICAL FISH. Bruce W. Halstead and Bonnie L. Landa. Golden Press. 1975. Middle School and others. 160 pages. Informational.

Illustrated in color with instructions for setting up and maintaining an aquarium. Includes notes on fish health. Most of the book is an illustrated manual of tropical fish with notes on their care. Useful.

TURTLES, TORTOISES, AND TERRAPINS. John Goode. Charles Scribner's Sons. 1971. Middle School and others. 63 pages. Informational.

Nicely illustrated with 26 black-and-white drawings of a wide variety of the world's "turtles." Describes something about their evolution, anatomy, reproduction, migration, and the problems man has caused them. There are instructions for keeping turtles as pets, a glossary, and index.

THE TWILIGHT SEAS--A BLUE WHALE'S JOURNEY. Sally Carrighar. Weybright and Talley. 1975. Upper Middle School. 179 pages. Fiction.

Describes a blue whale's life and journey, including unhappy encounters with humans. Beautiful black-and-white drawings and interesting well written details make this a valuable reading experience. No bibliography or index.

UNDER THE SEA-WIND. Rachel Carson. New American Library. 1941. Grades 7 and up. 157 pages. Fiction.

An obvious love and understanding of the interdependence and life of the sea is conveyed in Carson's book. She selects several animals of different species to follow closely as they affect and are affected by their environment. Beautifully written.

UNDERWATER ZOOS. Millicent E. Selsam. William Morrow & Co. 1961. Grades 5 and up. 96 pages. Informational.

The building and maintenance of fresh and salt water aquariums are discussed in this book. Appropriate animals, plants, and water conditions are clearly cited for those who would like to begin their own underwater zoos. Simple drawings support the text.

VEIN OF IRON. Walter Havighurst. The World Publishing Company. Cleveland, Ohio. 1958.

THE VIKINGS. J. R. L. Anderson. Penguin Books, Inc. 1974. Grades 5-6. 48 pages. Informational.

A kinder look at this infamous group than is usually seen. Their origin, life-style, voyages, crafts, and pirating raids are described. Color and pen-and-ink drawings help present a clearer picture of the Vikings' way of life.

THE VOYAGES OF COLUMBUS. Rex and Thea Rienits. The Hamlyn Publishing Group, Ltd. 1970. Upper Middle School and up. 151 pages. Informational.

Describes the life and time of Christopher Columbus, including early America, the European culture at the time, the four voyages, and the aftermath. Attractively and profusely illustrated with 47 color plates and many black-and-white illustrations. The problem Columbus had in gaining support for his proposals, and later, in fighting for recognition are well developed. There is a list of suggested readings and a two-page index.

THE VOYAGES OF DR. DOLITTLE. Hugh Lofting. J. B. Lippincott Co. 1950. Upper Middle School. 364 pages. Fiction.

The storybook that won an award as "the most distinguished contribution to American literature for children." Tells the story of Dr. Dolittle's voyage to Spidermonkey Island with young Tommy Stubbins during which they have continuous, fabulous adventures. The story has a happy ending and very few illustrations.

WATER AND MARSH BIRDS OF THE WORLD. Oliver L. Austin. Golden Press. 1967. 223 pages. Informational.

Describes the major groups of water and marsh birds with primarily generalized natural history narratives.

THE WAVES. Herbert Zim. William Morrow & Company, 1967. Upper Intermediate. 63 pages. Informational.

Water in motion, better known as waves, is explained in this book. Technical studies of waves and their significance are discussed. Also mentioned are tidal waves, their past destructiveness, and current warning devices used by the Coast and Geodetic Survey. Illustrated with pencil drawings.

WHAT DOES AN OCEANOGRAPHER DO? John F. Waters. Dodd, Mead & Co. 1970. Upper Intermediate. 64 pages. Informational.

Explains the science of oceanography and describes the work and studies of oceanographers. The biological, chemical, physical, and geological aspects of oceanography are delineated. Illustrated with black-and-white photographs.

WHEN THE TIDE GOES FAR OUT. Lorus and Margery Milne. Atheneum Publishers. 1970. Upper Intermediate. 88 pages. Informational.

A description of the animals and plants that can be found on the beach "when the tide goes far out." Also describes how the tides are caused and why the sea is important. All new terms are explained.

WHERE THEY GO IN WINTER. Margaret Waring Buck. Abingdon Press. 1968. Upper Intermediate. 69 pages. Informational.

The author tells what happens to the many kinds of animals we see in warm weather when the cold weather arrives. Her discussion includes the part of the United States that has a cold winter season. The book is divided into chapters devoted to insects, fishes, birds, reptiles, amphibians, and mammals. Pencil drawings in the margins illustrate this book.

THE WHITE PALACE. Mary O'Neill. Thomas Y. Crowell Co. 1966. Lower Intermediate. 48 pages. Fiction (poetic story).

This is an animal fiction story that conveys information to the reader. It is the story of the life cycle of a Chinook salmon. His life begins and he moves into the "white palace." A plot develops and the author's descriptions of the fish's behavior and habitat are credible. Wash drawing illustrations are used in this book.

THE WONDERFUL WORLD OF THE SEA. James Fisher. Doubleday & Co. 1970. Upper Middle School and up. 96 pages. Informational.

A comprehensive coverage of: the origins and physical features of the seas; the sea's living inhabitants and their contributions to evolution; and the role of the sea in war, transportation, and food production. There is a 22-page encyclopedic glossary and a three-page index.

THE WONDERS OF ALGAE. Lucy Kavaler. John Day Co., Inc. 1961. Upper Intermediate. 96 pages. Informational.

Describes the current and possible future uses of algae.

WONDERS OF AN OCEANARIUM. Lou Jacobs, Jr. Golden Gate Junior Books. 1965. Middle School. 80 pages. Informational.

Discusses the life forms commonly found in large aquaria for public viewing and/or research. Well illustrated with black-and-white photographs. Close-ups of fish, octopi, turtles, seals, walruses, whales, otters, and dolphins are shown.

WORLD BENEATH THE OCEANS. T. F. Gaskell. Natural History Press. 1964. Middle School. Informational.

A reference book about man's adventures with the oceans of the world as they have developed from early times until the time of the book's publication. The floors of the oceans are described as are the movements of the water. Plant and animal life found in the deep are also described. Illustrated with drawings and photographs.

THE YEAR OF THE SEAL. Victor B. Scheffer, Charles Scribner's Sons. 1970. Upper Middle and others. 200 pages. Fiction.

By interweaving the lives of seals and humans, the author achieves a sensitive and engrossing account of a year in the life of an Alaskan fur seal. The viewpoint of the wildlife biologist is dominant and the writing is clearly authoritative but warm-hearted and sensitive. Bibliography and index are included.

THE YEAR OF THE WHALE. Victor B. Scheffer. Charles Scribner's Sons. 1969. Grades 7-12. 213 pages. Fiction.

Marine biologist Victor Scheffer wrote the story of a newborn sperm whale's first year of life. Straightforward scientific exposition is sandwiched in the fictionalized narration. The author has included six pages of reference notes and an annotated bibliography of seven whaling classics. There is an index also. This book won the 1969 Burroughs Medal.

YOU AND THE OCEANS. Diane Sherman. Childrens Press. 1965. Lower Intermediate. 61 pages. Informational.

An introductory book about oceanography. Explains the ocean's beginnings, the interaction of sea and land, the ocean floors, and movements of the oceans. Discusses discoveries from the sea and future possibilities for new uses of the ocean and its resources. Pastel drawings are used to illustrate this book.

YOU CAN MAKE SEASIDE TREASURES. Louis Beetschen. Pinwheel Books. 1971. Middle School and others. 32 pages. Informational.

Describes a number of arts and crafts activities that can be done with sand and other items commonly found on beaches. Included are sand molding, making shell necklaces, painting pebbles, building sand castles, and collecting shells. Also includes games to be played at the beach.

YOUNG SPORTSMAN'S GUIDE TO SURFING. Ross R. Olney. Scholastic Book Services. 1965. Upper Middle School and others. 96 pages.

An introductory surfing manual with black-and-white photographs. Practical pointers from experts. Inexpensively produced. Glossary included.

LIST OF SUGGESTED FILMS

All films on this list (except where otherwise indicated), may be obtained without charge by writing to:

Motion Picture Service
Department of Commerce -- NOAA
12231 Wilkins Avenue
Rockville, Maryland 20852
(301) 443-8411

THE BIOLOGIST AND THE BOY. 14 minutes. An encounter between a biologist and a boy on the Gulf of Mexico. Discusses conservation and awareness.

ESTUARINE HERITAGE. 28 minutes. Shows threats to estuarine resources and stresses the importance of estuaries.

ESTUARY. 28 minutes. Stresses the value of the estuary and its uses for food resources and recreation.

THE GREAT AMERICAN FISH STORY. 28 minutes. A series of five films (each is 28 minutes long) which tells the story of the American fishing industry. The first film is an overview and the other four each concentrate on one area of the country -- The West, The Northeast, The South, The Lakes and Rivers. Every aspect of the fishing industry is covered from catching to cooking.

HURRICANE. 27 minutes. Shows warning methods for hurricanes. Emphasizes safety precautions for life and property. To obtain: Film Librarian, Public Relations and Advertising Dept., Aetna Life and Casualty, 151 Farmington Ave., Hartford, Conn. 06115. (203) 273-0123.

HURRICANE DECISION. 14 minutes. A hurricane awareness and preparedness film. Points out the dangers of storm surge, wind and inland flooding caused by hurricanes.

IT'S YOUR COAST. 28 minutes. Discusses coastal zone problems with people from Florida, Maine, Illinois and Washington. Land development, oil pollution, and beach erosions are discussed. Stresses the importance of the coast.

WATERMEN OF CHESAPEAKE. 28 minutes. A film about the impact of Chesapeake Bay on a large segment of America.

GAMES

THE THERMAL POLLUTION GAME. Educational Research Council of America, a board game for 4 players about the pollution over time of two rivers in "Central City."

DIRTY WATER. Judith Anderson, Helen Trilling, and Richard Rosen; Urban Systems, Inc., a board game for grades 4 to 12 for 2 to 4 players about the problems of maintaining an ecologically balanced lake.

WHERE TO OBTAIN DATA*

The following paragraphs give detailed information on the types of data available from different sources and show how to obtain it.

1. EARTH RESOURCES OBSERVATION SYSTEM (EROS)

Earth resource data can be obtained by writing to the EROS Data Center, a division of the Department of the Interior.

EROS
Data Management Center
Sioux Falls, SD 57190

The EROS Data Center will assist in locating imagery and photography to suit the particular needs of the user. The center's computerized storage and retrieval system is based on geographical coordinates (latitude and longitude), the date and time of day the photographs were obtained, and the scale of the photographs.

The requestor may provide the center with the latitude and longitude of the point of interest, or may define an area by giving latitude and longitude of a maximum of eight perimeter points. On receipt of a request the center staff will locate the area of interest and will prepare a listing of photographs from which the requestor can make the final selection.

EROS stocks Skylab photographs as well as LANDSAT (ERTS) photographs. The Skylab spacecraft operated at about half the altitude of LANDSAT. Consequently Skylab photographs contain more detail than LANDSAT.

If you elect to use Skylab photographs in your study, it is possible to help EROS speed up your order by quoting the specific photograph numbers of the scene you need. You can write to the following address for help.

Lyndon B. Johnson Space Center
Research Data Facility
Mail Code TF-8
Houston, TX

Include the names of prominent features in the area. City names, rivers, and mountains should be included as well as latitude and longitude. Research Data Facility personnel will check through their catalogs and provide you with photograph identification numbers that you can then send to EROS to obtain the copies you need.

*National Aeronautics and Space Administration, <u>What's the Use of Land? A Secondary School Social Studies Project</u> (Jefferson County, Colorado, Public Schools), 1976, pp. 32-35. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.45, Stock Number 033-000-00665-9).

At the time of writing the prices of black and white EROS photographs ranged from $1.25 to $9.00. Color reproductions cost about three times as much as black and white. For more details write to EROS at Sioux Falls, South Dakota.

Another outlet for EROS services is located in Bay St. Louis, Mississippi. At the National Space Technology Laboratories, anyone can obtain a wide variety of earth resources information and order photographs by writing to:

National Space Technology Laboratories
Bay St. Louis, MS 37520

2. U. S. GEOLOGICAL SURVEY

U.S. Geological Survey (USGS) maps are available from any regional Federal Center and from certain commercial stores such as sporting goods stores. The most common USGS maps are of an area 7½ minutes square or 15 minutes square.

3. SKYLAB EARTH RESOURCES DATA CATALOG

The Skylab Earth Resources Data Catalog prepared by NASA, provides a complete index of Skylab earth resources photographs and other data, plus direction on how copies can be obtained. It also provides a discipline-by-discipline review of possible uses of the Skylab photographs and data with appropriate illustrations.

In marine resources data, channels, shallow areas, river discharges of sediment, and other features of waterways often show up better from space than by any other means.

The environment data deal, in a broad sense, with man's environment. The data also proved particularly useful regarding specific environmental problems. Sources of water and air pollution often can be located and the spread of contaminants traced for long distances in a single photograph.

The Skylab Earth Resources Data Catalog is obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Price $12.50). The book number is GPO-3300-00586.

WHERE TO GET INFORMATION?

Federal Sources of Information

Numerous Federal agencies are involved in matters affecting the coastal zone. Many have special expertise and information that will be of use to citizens who are participating in the development of state management plans. For example they may have data that permits state information to be cross-checked or supplements it with a regional or national perspective. The following are some of the best sources of information.

Office of Coastal Zone Management/NOAA
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(clearinghouse for specialized coastal zone technical information)

U.S. Fish and Wildlife Service
Washington, D.C. 20240
(can provide information on local waterfowl, game fish and endangered species)

National Marine Fisheries Service/NOAA
Page Building 2
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(data on commercial and sport fisheries)

Office of Sea Grant/NOAA
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(supports a large program of university research on ocean and coastal topics)

Department of Agriculture
Federal Soil Conservation Service and Cooperative Extension Agents
Washington, D.C. 20250
(can supply hydrological and soil data, also helpful in providing names of local experts and scientists)

State Coastal Management Program Managers

NORTH ATLANTIC REGION

Connecticut: Charles McKinney, Director, Coastal Area Management Program, Department of Environmental Protection, 71 Capitol Avenue, Hartford, CT 06115

Maine: Alec Griffen, State Planning Office, Resource Planning Division, 189 State Street, Augusta, ME 04333

Massachusetts: S. Russell Sylva, Assistant Secretary, Executive Office of Environmental Affairs, 100 Cambridge Street, Boston, MA 02202

New Hampshire: La[illegible] Ross, Division of Regional Planning, Office of Comprehensive Planning, State Annex, Concord, NH 03301

New Jersey: David Kinsey, Chief, Office of Coastal Zone Management, Department of Environmental Protection, P.O. Box 1889, Trenton, NJ 08625

New York: Robert Hanson, Director, Division of State Planning, Department of State, 162 Washington Street, Albany, NY 12231

Rhode Island: Daniel Varin, Statewide Planning Program, Department of Administration, 265 Melrose Street, Providence, RI 02907

SOUTH ATLANTIC REGION

Delaware: David Hugg, Coastal Management Program, Office of Management, Budget and Planning, James Townsend Building, Dover, DE 19901

Georgia: James Dodd, Planning Division, Office of Planning & Budget, 270 Washington Street, S.W., Room 613, Atlanta, GA 30334

Maryland: Suzanne Bayley, Department of Natural Resources, Energy & Coastal Zone Administration, Tawes State Office Building, Annapolis, MD 21401

North Carolina: Ken Stewart, Department of Natural & Economic Resources, Box 27687, Raleigh, NC 27607

South Carolina: Wayne Beam, Wildlife and Marine Resources Department, 1116 Bankers Trust Tower, Columbia, SC 29201

Virginia: Don W. Budlong, Office of Commerce and Resources, 5th Floor, Ninth Street Office Building, Richmond, VA 23219

GULF/ISLANDS REGION

Alabama: Dr. Bruce Trickey, Executive Director, Coastal Area Board, General Delivery, Daphne, AL 36526

Florida: Dr. Ted LaRoe, Bureau of Coastal Zone Planning, Department of Environmental Regulation, 2562 Executive Center Circle East, Montgomery Building, Tallahassee, FL 32301

Louisiana: George A. Fischer, Secretary, Department of Transportation and Development, P.O. Box 44486, Baton Rouge, LA 70804

Mississippi: Jerry Mitchell, Mississippi Marine Resources Council, P.O. Drawer 959, Long Beach, MS 39560

Puerto Rico: Frank A. Molther (Acting), Department of Natural Resources, P.O. Box 5887, Puerto de Tierra, PR 00906

Texas: Ron Jones, Director, Texas Coastal Management Program, General Land Office, 1700 N. Congress Avenue, Austin, TX 78711

Virgin Islands: Darlan Brin, Virgin Islands Planning Office, P.O. Box 2606, Charlotte Amalie, St. Thomas, VI 00801

GREAT LAKES REGION

Illinois: Chris Shafer, Illinois Coastal Zone Management Program, 300 N. State Street, Room 1010, Chicago, IL 60610

Indiana: T. "Ted" Pantazis, State Planning Services Agency, 143 West Market Street, Harrison Building, Indianapolis, IN 46204

Michigan: Merle Raber, Coastal Zone Management Program, Department of Natural Resources, Division of Land Use Programs, Stephen T. Mason Building, Lansing, MI 48926

Minnesota: Roger Williams, State Planning Agency, Capitol Square Building, 550 Cedar Street, Room 100, St. Paul, MN 55155

Ohio: Bruce McPherson, Department of Natural Resources, Division of Water, 1930 Belcher Drive, Fountain Square, Columbus, OH 43224

Pennsylvania: George E. Fogg, Chief, Division of Outdoor Recreation, Department of Environmental Resources, Third & Reily Sts., P.O. Box 1467, Harrisburg, PA 17120

Wisconsin: Al Miller, Office of State Planning & Energy, One West Wilson St., B-130, Madison, WI 53702

PACIFIC REGION

Alaska: Glenn Akins, Policy Development & Planning Division, Office of the Governor, Pouch AD, Juneau, AK 99801

California: Joe Bodovitz, California Coastal Zone Conservation Commission, 1540 Market Street, San Francisco, CA 94102

Guam: David Bonvouloir, Bureau of Planning, Government of Guam, P.O. Box 2950, Agana 96910

Hawaii: Dick Poirier, Department of Planning & Economic Development, P.O. Box 2359, Honolulu, HI 96804

Oregon: Jim Ross, Land Conservation & Development Commission, 1175 Court St., N.E., Salem, OR 97310

Washington: Rod Mack, Department of Ecology, State of Washington, Olympia, WA 98504

SEA GRANT INSTITUTIONS

Pam Johnson and Linda Weimer have summarized Sea Grant activities and publications that are relevant to elementary and secondary schools. Write for Informal Survey of K-12 Publications. University of Wisconsin, Sea Grant College Program, 1800 University Avenue, Madison, WI 53706, July 1977. Information may also be requested directly from state Sea Grant Marine Advisory Services.

Alaska: Marine Advisory Service, 3211 Providence Avenue, Anchorage, AK 99504

Alabama: Resource Use Division, Cooperative Extension Service, Auburn University, Auburn, AL 36526

California: Marine Advisory Program, University of California, Davis, CA 95616

Connecticut: Marine Advisory Service, University of Connecticut, 322 N. Main Street, Wallingford, CT 06492

Delaware: Marine Advisory Service, College of Marine Studies, University of Delaware, Newark, DE 19711

Florida: Marine Advisory Program, 3002 McCarty Hall, University of Florida, Gainesville, FL 32611

Georgia: Sea Grant Program, University of Georgia, 110 Riverbed Road, Athens, GA 30602

Hawaii: Sea Grant Programs Office, University of Hawaii, Spalding Hall, Room 255, 2540 Maile Way, Honolulu, HI 96822

Louisiana: Sea Grant Program, Coastal Studies Building, Louisiana State University, Baton Rouge, LA 70803

Maine: Cooperative Extension Service, Univ. of ME Marine Lab., Walpole, ME 04573

Maryland: Cooperative Extension Service, 1224 Symons Hall, University of Maryland, College Park, MD 20742

Massachusetts: MIT Sea Grant Program, MIT, Room 1-211, 77 Massachusetts Avenue, Cambridge, MA 02139

Michigan: Coordinator, Advisory Service, Michigan Sea Grant, 2200 Bonisteel Boulevard, University of Michigan, Ann Arbor, MI 48105

Minnesota: Marine Advisory Service, 325 Administration Building, University of Minnesota, Duluth, MN 55812

Mississippi: Sea Grant Advisory Service, Box 4557, Biloxi, MS 39531

New Jersey: Marine Science Center, Rutgers University, New Brunswick, NJ 08903

New Hampshire: UNH Sea Grant Marine Advisory Service, Kingsbury Hall, University of New Hampshire, Durham, NH 03824

New York: NY Sea Grant Advisory Service, Fernow Hall, Cornell University, Ithaca, NY 04853

North Carolina: Extension & Public Service NC State University, 133, 1911 Building, Raleigh, NC 27607

Ohio: Extension Wildlife Specialist, 232 B Howlett Hall, 2001 Flyffe Center, Ohio State University, Columbus, OH 43210

Oregon: Marine Advisory Program, OSU Marine Science Center, Newport, OR 97365

Pennsylvania: Urban Forest Wildlife Specialist, 11 Ferguson Building, Pennsylvania State University, University Park, PA 16802

Rhode Island: Marine Advisory Service, University of Rhode Island, Narragansett Bay Campus, Narragansett, RI 02882

South Carolina: Marine Resources Center, P.O. Box 12559, Charleston, SC 29412

Texas: Education & Advisory Services, Center for Marine Resources, Texas A & M University, College Station, TX 77843

Virginia: Dept. of Advisory Services, Virginia Institute of Marine Scinece, Gloucester Point, VA 23062

Washington: Washington Sea Grant Marine Advisory Program, University of Washington-HG30, Seattle, WA 98195

Wisconsin: Advisory Services, 420 Lowell Hall, 610 Langdon Street, Madison, WI 53706

RESOURCES FOR COASTAL STUDIES

CURRICULUM MATERIALS CATALOGS

A Catalog of Curriculum Materials for Marine Environment Studies: Elementary, Secondary. 38 pages, $1.00

A List of Books on the Marine Environment for Children and Young People. Annotated, 65 pages, $2.00

Audio-Visual Aids, Games, and Art for Marine Environment Studies. Annotated, 89 pages, $2.00

An annotated Bibliography of Periodical Sources for Marine Environment Studies, Newsletters, Bulletins, Journals, and Magazines. 21 pages, $1.00

All these are available from Project COAST, 310 Willard Hall, University of Delaware, Newark, DE 19711

A Bibliography of Elementary and Secondary Marine Science Curriculum Projects and Education Materials. University of Rhode Island Marine Bulletin Series #15. 23 pages, New England Marine Resources Programs, Narragansett, RI 02882

A Partial Bibliography for Precollege Marine Science Educators. 94 pages, University of Maine Sea Grant. Orono, ME 04473

NON-SCHOOL ORGANIZATIONS

League of Women Voters
1730 M Street, N.W.
Washington, D. C. 20036

Brochures: Coastal Zone Management. 1975
The Onshore Impact of Offshore Oil. 1976
Energy and Our Coasts: The 1976 CZM Amendments. 1977

Florida 4-H
Florida Sea Grant
Florida Maine Advisory Program
University of Florida
Gainesville, Florida

Study: Interest in coastal states in developing marine education programs.

Call : Local Department of Agricultural Extension Service for information on local 4H marine education projects.

Marine Ecological Institute
811 Harbor Boulevard
Redwood, California 94063

Discovery marine voyages: Around San Francisco area, fee.

Jean-Michel Cousteau Institute
P. O. Drawer CC, Harbor Town
Hilton Head Island, South Carolina

Workshops: "Man and the Sea" in Savannah, Georgia and Charleston, South Carolina, fee.

Coastal Management Programs
Coastal States

Newsletter: Describes local coastal problems, issues and proposed solutions. For addresses see list of state coastal management programs in section on "Where to Get Information".

ASSISTANCE IN COASTAL AND MARINE EDUCATION

National Marine Education Association
546-B Presidio Boulevard
San Francisco, California 94120

Newsletter and Annual Conference: Contact Thayer Schafer, Exec. Secy. Membership $15

Sea World (Formerly, The Journal of Marine Education)
Sea World Communications
1250 Sixth Avenue
San Diego, California 92101

Magazine: Published quarterly, includes section on curriculum (included in $15 membership in National Marine Education Association).

Marine Education Materials System
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

Microfiche copies of marine education materials; Inexpensive, ask for list of materials available.

Dr. Francis Pottenger
Curriculum Research and Development Group
College of Education, University of Hawaii
1776 University Avenue
Honolulu, Hawaii 96822

Coastal Studies Course: Designed for 11th and 12th graders, includes ecology, economics, and government and involves students in coastal issues and management systems. Write for information on the course and teacher training.

GLOSSARY

GLOSSARY:

Algae:
Simple aquatic plants, without true stems, leaves, or roots, that vary in size from microscopic, unicellular forms to multicellular forms more than 30.5m (100 ft) long

Arthropods:
Segmented invertebrates with jointed legs, including arcachnids insects, and crustaceans

Barrier islands:
Low offshore islands stretching parallel to the shore and separated from the mainland by a small body of water; in the United States found mainly on the Atlantic coast (from New Jersey south), along the Gulf of Mexico, and in the Pacific only in north Alaska and in an area along the coast of northern Oregon and southern Washington

Bay:
A wide inlet of water, indenting the shoreline and forming a protected area along the shore of a sea or lake

Bayou:
A marshy, sluggish tributary to a lake or river; from the Louisiana French version of the Choctaw word bayuk

Beach:
A shoreline area washed by waves and composed of sand or pebbles

Beach grass:
A strongly rooted plant common on sandy shores that helps to anchor and build the dunes

Berm:
A narrow shelf, path, or ledge typically at the top or bottom of a slope.

Breakwater:
A barrier constructed of large rocks or concrete to provide protection for beaches or harbors by breaking the force of wave action. Groins, jetties, and sea walls are all forms of breakwaters

Coast:
Land next to the sea; seashore

Coastal management:
The development of policies and regulations to insure wise control, development, and use of coastal resources

Coastal pond complex:
A land and water composite that consists of a barrier beach, sand dunes, marsh, and pond; small off-shore islands and freshwater streams and wetlands are sometimes included

Coastal resources
Anything that gives a source of supply, support, or aid in maintaining the value of the coastal region. The value can be counted in various terms: monetary (oil, ports, fish), ecological (plankton, dunes, shorebirds), cultural (historic areas), aesthetic (scenic bluffs, clear blue water) or recreational (marinas, beaches)

Continental shelf:
The ocean floor along the coastline that is submerged in the relatively shallow sea; the sunlit, submerged land from the coast to the brink of the deep ocean

Coral reef:
A colony of marine animals with skeletons containing calcium carbonate that, massed together, form islands or ridges near the surface of the sea in tropical areas (found only in Florida and Hawaii in the United States)

Crustacean:
Any mostly aquatic arthropod, typically with a hard shell covering the body; includes lobsters, shrimps, crabs, and barnacles

Delta:
The area where river sediment is dropped at the mouth of a river flowing into an ocean or large lake; frequently triangular in shape made up of marshy areas, lagoons, and lakes

Detritus:
A sediment of small particles found on the ocean bottom made up of the remains of plants and animals and the disintegration of rocks; an important link in many food chains

Dock:
A platform extending into the water to which a boat is tied or where passengers and gear are loaded or unloaded

Downdrift:
Describes direction of sand movement with the prevailing current

Dune:
Elliptical or crescent-shaped mound of sand formed by wind action. The windward slopes of dunes are gentle, the lee sides steep. In crescent-shaped dunes the convex side faces the direction from which the wind is blowing. Sand blown up the windward side drops down the lee slope, causing the dunes to migrate slowly

Eelgrass:
A grasslike marine herb with ribbonlike leaves that grows on sand and mud-sand bottoms in shallow coastal waters

Estuary:
The zone where the fresh water of a river mixes with the salt water of the sea; rich in biological activity

Flood plain:
The flat area along a river that is subject to flooding at high water periods

Food chain:
A series of organisms in which members of one level feed on those in the level below it and are in turn eaten by those above it; there is a 10 to 1 loss in bulk as the food chain moves upward. It takes a 1000 kilograms of phytoplankton to make 1 kilogram of shark

Food web:
The interconnected food chains of a biological community

Groin:
Breakwater structure constructed outward into the sea or a lake to reduce drifting of beach sand along the shore

Harbor:
A sheltered area of water deep enough for ships to anchor or moor for loading and unloading; may be natural (bays) or artificial (within breakwaters)

Intertidal zone:
The area along the shoreline that is exposed at low tide and covered by water at high tide

Island:
A body of land completely surrounded by water and too small to be called a continent

Isopod:
Any fresh-water, marine, or terrestrial crustacean having seven pairs of legs and a flat body

Jetty:
A pier or structure projecting into the water to protect a harbor or deflect a current

Lagoon:
A body of brackish water separated from the sea by sandbars or coral reefs

Lake:
A large body of fresh or salt water completely surrounded by land

Littoral:
Pertaining to the shore of a lake, sea, or ocean

Mangrove:
A moderate-sized tree which grows on low, often submerged coastal lands, noted for the land-forming function of its intricate mass of arching prop roots which trap silt and debris floating in the water

Ocean:
The entire body of salt water (seawater) that covers almost three-fourths of the earth's surface

Oil rig:
A structure for drilling and pumping oil from beneath the ocean floor to the water's surface

Pier:
A fixed or floating platform attached to piles or posts over the water from the shore; may be used for mooring boats or ships, fishing, etc.

Pond:
A body of still water, fresh or salty, that is smaller than a lake; frequently constructed to hold water

Port:
A town or city located at a bay or harbor where waterborne transportation takes place; from the Latin for house door

Riprap:
Broken stone or other material piled along a shore to protect it from erosion by wave action

River:
A fairly large-sized natural stream of water flowing in a definite course from an area of higher elevation to lower elevation. The term "river" is sometimes used incorrectly to define narrow tidal inlets

Rocky cliff:
The high steep face of a rock mass that forms the most erosion-resistant areas along the shore

Salinity:
The measure of the quantity of dissolved salts in seawater

Salt marsh:
An area of low-lying, wet land with heavy vegetation that is washed by tidal action from the sea

Sand:
A mixture of tiny grains of different types of disintegrating rocks and shells found along beaches

Sandbar:
An off-shore shoal of sand resulting from the action of waves or currents

Sea wall:
A barrier constructed along the edge of a shore to prevent erosion from wind or wave action; sometimes called bulkhead or revetment

Seawater:
The water of the ocean which is distinguished from fresh water by its salinity

Seaweed:
Any plant growing in the sea, specifically marine algae like kelp, rockweed, and sea lettuce

Shore:
The space between the ordinary high water and low water marks

Shoreline:
Where the land and water meet

Sound:
A narrow passage of water forming a channel between the mainland and an island or connecting two larger bodies of water such as a bay and an ocean

Spit:
A narrow point of land extending into the sea or a lake formed by waves and currents; subject to shifting

Tide:
The twice-daily rise and fall of the waters of the ocean and its inlets produced by the gravitational attraction of the moon and sun

Tidal pool:
A small body of water along rocky shores left by the retreat of the tide; a unique environment for many plant and animal species that can withstand highly variable moisture, salinity, and temperature conditions as well as high winds and pounding waves

Trophic:
Having to do with nutrition

Wave-cut cliff:
The steep slope of the shore cut by wave action

Wetlands:
Areas such as fresh and salt-water marshes, bogs, or swamps that remain wet and spongy most of the time

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